COLLEGE OF ENG

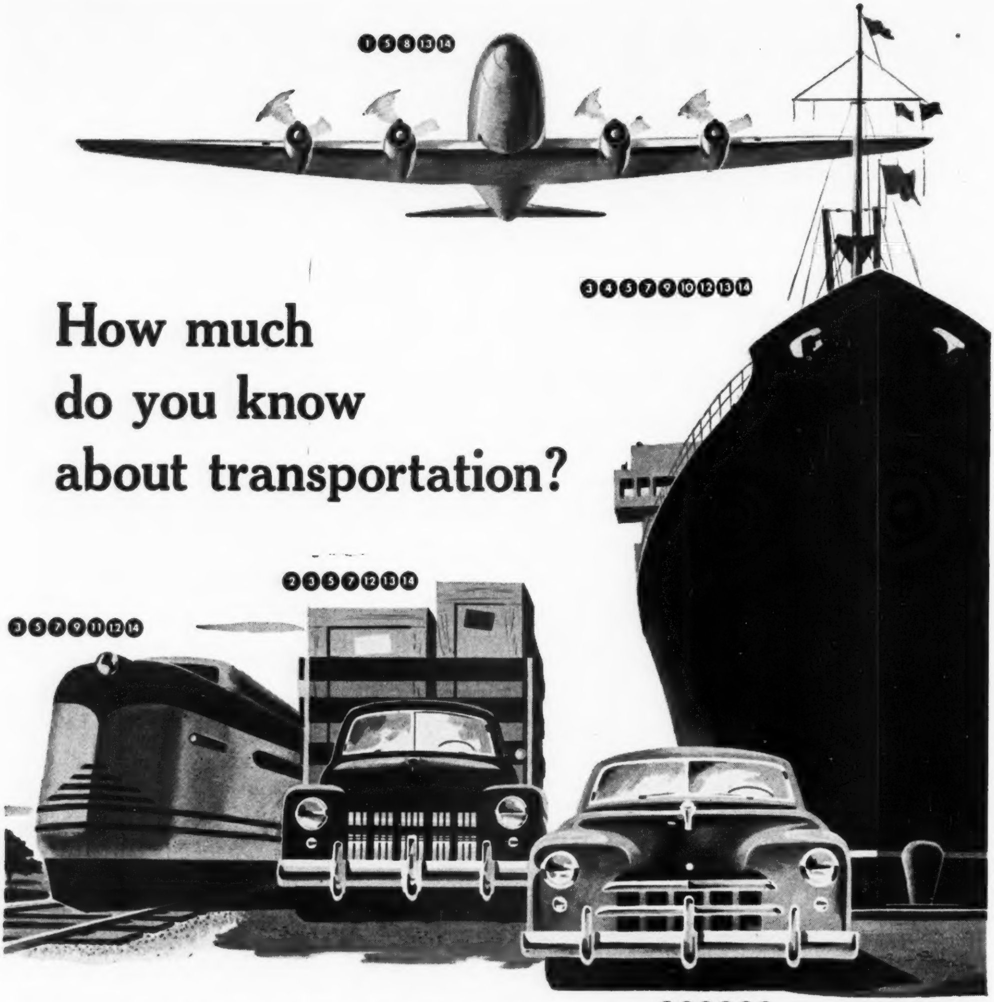
# The Cornell

NOVEMBER, 1951

VOL. 17, NO. 2

25 CENTS


HE never heard of Refractories...

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# The CORNELL ENGINEER

Volume 17 November, 1951 Number 2

CONTENTS



**Cover**—Cornell's new president discusses campus affairs with Leila Pincus, Ag '55, Jerry Adler, ILR '53, and Steve Goodman, Arts '54.

*—Stuckelman*

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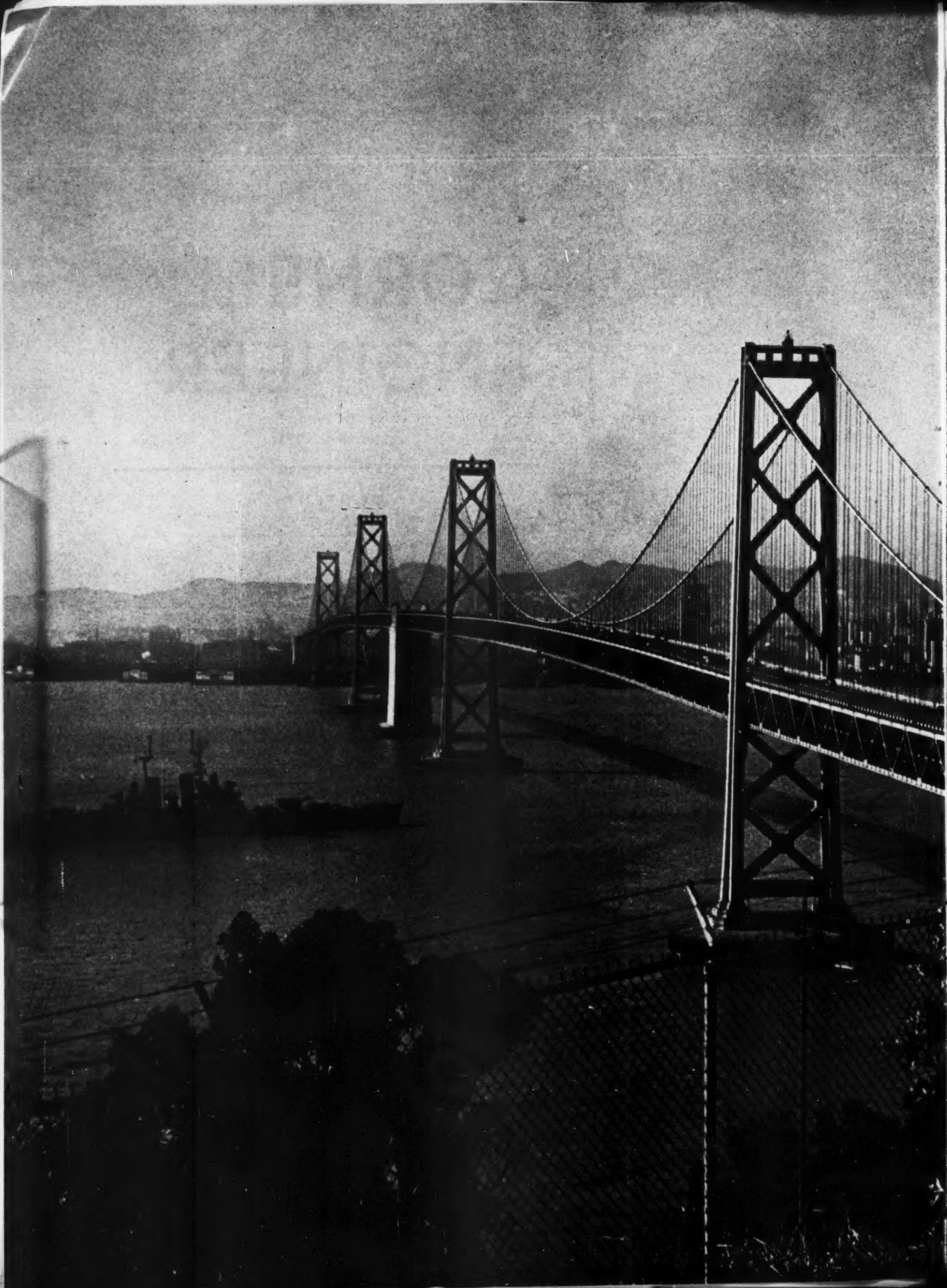


# WELDSPAN

## A New Type of Bridge Construction

By THOMAS RICE ROLLO, C.E. '10

The failure of the Tacoma Narrows bridge several years ago, in which the wind built up such large oscillations that it collapsed, is only one of a series of bridge failures reflecting on the entire field of engineering design, and more especially on the ability of the civil engineer to attack problems successfully. The Cornell school of thought is designed to foster new inventions through combinations of wide and well chosen branches of science, and proves generally successful.

Perhaps the most significant contributor to this field in our times has been Vierendeel, with his all-welded truss. It is purely a coincidence that recent attention has been called to an isolated instance of one of the Vierendeel truss failures. That could happen likewise to any truss because of faulty materials, workmanship, or abuses like overloading in service. The Vierendeel truss that inspired this research into bridges is a heavy-duty railroad bridge that successfully withstood not only shellfire and aerial bombing, but the efforts of a demolition squad.

Fairness compels mention of Dr. Steinman's Florianapolis Truss, but it must be conceded that Steinman is primarily a follower of John A. and Washington Roebling. His truss is simply a modification of Roebling's stiffening trusses. His recommendations in the Tacoma Narrows investigation have dealt solely with Roebling's principle of diagonal stays and more diagonal stays, both above the bridge floor and below it.

Oakland Bay Bridge, with San Francisco in the background. —*Free-Lance*

For purposes of discussion the new truss has been termed "Weldspan," a term merely chosen for brevity and convenience.

A prerequisite of this design was the elimination of all factors causing long-span bridge failures. With causes determined and eliminated, a long step has been taken toward utilizing the advances in science.

Another prerequisite was the return to the basic principle, as indicated in the name, i.e. pure suspension. This, in itself, presents something of a problem in view of authoritative statements to the contrary attributed to the designers above mentioned.

The "method of rightly conducting the reason" is known as logic. So one must begin by choosing only from among known truths entirely free from doubts and prejudices. We glance with amused pity at the type of mind that could express the principle, "We had assumed a prevailing wind angle of about 7° for the design that failed, *so we began the new design on the same assumption.*" (The italics are mine.) I am sure the designer was blissfully unaware of his lapse, just as I am confident he never read any logic.

It is believed that a brainier (or more lazy) aborigine than his fellows first observed that it was too much work climbing down one side of a gorge and up the other. So he wove a rope of tough vegetable fibers and made a swing from an overhanging tree in order to travel across with greater efficiency. Perhaps, after having tied it up to the other side, he noticed that he could leave it there and travel across it hand over hand.

This, in turn, undoubtedly led to the swinging bridge and the practical use of wire rope and steel. Even so, men were compelled to use factors of safety running up as high as 6, 8, and 10, due to the limita-

### ABOUT THE AUTHOR

**Thomas Rice Rollo started in on bridges at the age of ten under the influence of a civil engineer recently returned from Central and South America. He came to Cornell in 1906, and served for two years as apprentice to Prof. Church, Acting Head of Civil Engineering. He was a member of A.S.C.E., Rod and Bob, and the Editorial Board of the Cornell Civil Engineer, one of this magazine's predecessors.**

**On graduation in 1910, he was placed with the U. S. Coast and Geodetic Survey. Other plans necessitated short excursions into the economic fields of finance and industry, developing into specialization in consultations in pure water supply, mining, and finally long-span suspension bridges. He is now a consulting engineer at Wyocena, Wisconsin.**

**He is a member of the Cornell Society of Engineers and the Cornell Society of Civil Engineers, both of Chicago, the U. S. Army Corps of Engineers, Reserves, the U. S. Navy Civil Engineers Corps, Reserves, and is an Honorary Doctor of Civil Engineering.**

**He has written "Redesign of Steel Highway Bridges Using Electric Arc Welding," and "Redesign of Steel Cantilever Bridges Using Electric Arc Welding.**

Whitestone Bridge in New York City, with added braces against swaying. Truss work above sides.

—Free-Lance

tions of such materials as timber and iron or soft steels filled with flaws.

At this point we pass rapidly through the period of riveted steel structures, pausing only to note the conclusions drawn from the first great electric arc welding structures, i.e. riveted structures require 20% more steel, and economy, variously estimated at 92 per cent of the control-structures cost, could be realized by using high-strength steels and welding rods. More of this later.

We now glance at some bridge failures and their causes:

| *Bridge Failure* | *Cause* |
|---|---|
| 1. Two English chain-suspended | 1. Blown down by wind |
| 2. Schuylkill Falls, wire-susp. | 2. Collapsed in a year under winter ice and snow |
| 3. Broughton Bridge, chain-susp. | 3. Under marching troops |
| 4. Angers, France, wire-susp. | 4. Under marching troops |
| 5. Wheeling bridge, susp. | 5. Windstorm |
| 6. Tacoma Narrows | 6. Mild gale |
| 7. Niagara Bridge, 1864 | 7. Wind and ice jam |
| 8. Niagara Bridge, 1938 | 8. High ice jam |
| 9. Niagara-Clifton (3 failures) | 9. Hurricane |
| 10. Quebec Bridge, 1907 | 10. Collapse during erection |
| 11. Licking River Susp. 1854 | 11. Collapsed under a load of cattle in two weeks |
| 12. Old Firth of Forth Trestle | 12. Impact of loaded train |

Certain comments are called for in spite of the causes noted above. For example, "under marching troops," one of the oldest bugbears of all builders of suspension bridges and catwalks, must be ruled out, as it is no longer considered a factor. The old command was to "Break step." Present day materials and factors of safety indicate that marching rhythms are negligible in a railway or highway suspension bridge.

Another commentary covers bridges washed off piers by rivers in flood. This is now so rare in view of known flood levels as to be merely a matter of clearances, bed bolts, and bed plates. Impacts from moving live loads can be eliminated as they are caused by railends at joints (now continuously welded up to 28 miles in length) and expansion joints in concrete slab pavements (now eliminated by continuous asphaltic concrete pavements and open grating floorings). Impacts from loose structural members are eliminated along with chain and eye-bar construction.

**Design Considerations**

Snow, ice, and wind loads are reduced to a minimum in Weldspan.

This leaves us with overloading, ice jams, and periodic structural oscillations. The first is not in the province of design. The second is preventable by correct pier and anchorage design. The third seems to be the real cause of most of our troubles.

Erection failures crop up from time to time and are not properly a function of design, although recent economic studies would seem to require a great deal more of the designer than is indicated in the specifications.

Here are a few designer's considerations:

Direct comparison of the materials and costs with an older structure of the same size.

Convertibility to wartime or peacetime uses.

Provision for industrial cities at the bridge site.

Provision for prefabrication both in the shop and at the site.

Provision for mass production, as for cities, counties, states, park systems, etc.

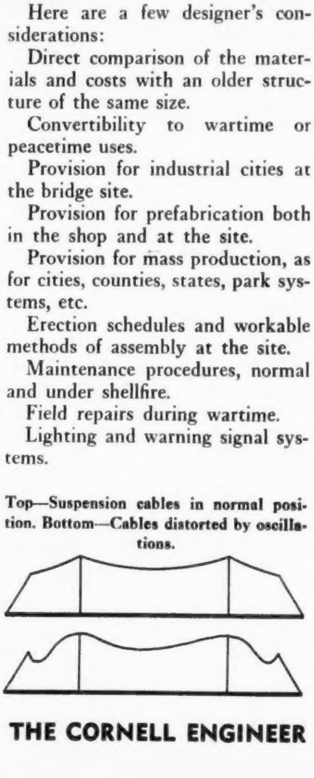
Erection schedules and workable methods of assembly at the site.

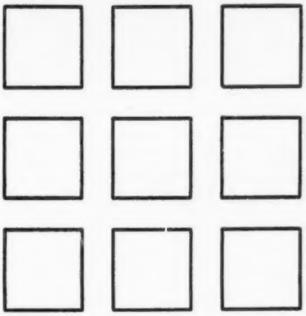
Maintenance procedures, normal and under shellfire.

Field repairs during wartime.

Lighting and warning signal systems.

Top—Suspension cables in normal position. Bottom—Cables distorted by oscillations.





Multi-cellular column, an assembly of individual square members.

Electricity, gas, water, and sewer conduit systems.

Regional planning and traffic surveys.

Relocation of air, rail, highway and water transportation facilities.

Resuming progress, our problem of periodic vibrations is immediately limited to ruptures caused by wind and oscillations. The early suspension bridges swung so much that men used to walk out on them to enjoy the sensation of a swing in the breeze (up to the 20th Century).

Now, how else besides dampening and stiffening methods could oscillations be held to within reasonable negligible limits?

We could have a structure in pure suspension or in pure tension (excepting for towers and floors, of course) while using rigid instead of flexible suspensory members.

This involves a little change in terminology, substituting "top chord" for "cable." It seems inescapably logical that if suspension bridges were not hung from flexible members, i.e. cables and suspenders, cumulative destructive motions could not be set up in them by periodic vibrations or winds from any angle.

The destruction from these causes is described as resulting from a picking up and slamming down of the entire floor system with enough force to snap suspenders and cables. In some cases there is a twisting action and the entire structure, floor, cables and towers are thrown into the water or irreparably damaged.

It is obvious that only a flexible member, like a cable, could be whipped out of position to any such extent as shown above.

Having arrived at a rigid top chord (by the process of elimination), we next consider materials and other factors involved in the requirements.

Silicon steel has been chosen for reasons of economy, leaving us with the following problems: structural shape, erection procedure, diversification of risk, field repairs, wind resistance, and snow load.

It seems obvious that to build a continuous concrete floor slab into a flexible suspended bridge structure would be about as fatal to static equilibrium as an attempt to fly a kite. The wind forces on such a floor under hurricane conditions would be virtually incalculable and certainly dangerous.

Let us suppose that, in time of war, the structure is severely damaged by enemy fire.

We are using a multi-cellular column assembly in the towers and a multi-rod assembly in the top chord and suspenders. The factor of safety is three. This not only reduces the wind and snow loads but permits field or emergency repairs even if two out of three sections of any member had been cut by enemy fire. See diagram.

**Bridge Specifications**

Likewise, the floor, a continuous open grating on a welded steel grill, not only eliminates impact, but minimizes wind and snow loads. The latter are further reduced by electric heating elements in the floor; also, it is rarely, if ever, that line loading occurs when snowfall renders highway traffic inadvisable.

To the above one may append the remaining specifications:

*Towers*—Two multi-cellular columns united by box-welded portal bracing make up each tower.

*Top Chord* — Rods, round or square (the latter is easier), spaced apart by the rod thickness and in any number that constitutes a square as 9, 16, 25, 36, etc., comprise the top chord. While not as numerous as assembled cable wires, they are nonetheless much more diversified and carry less wind and snow load than tubular or rolled sections in one piece. Top chords are continuous.

*Suspenders*—Like top chords, suspenders are an assembly of rods. Roughly, where the top chord might use 36 rods, the suspender would require 9.

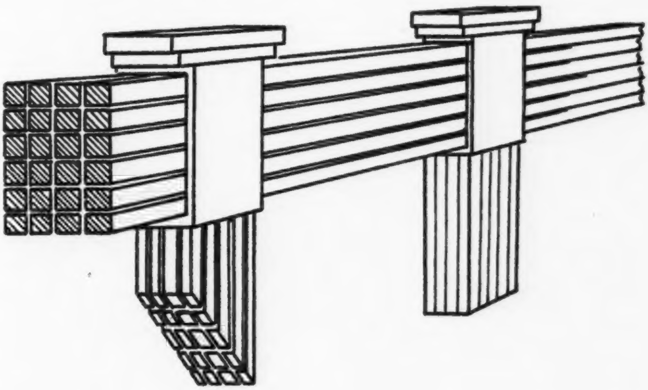
*Top Chord Suspender Assembly*—All rods unite in a box, roughly cubical in shape, made of welded plates, with Greek capital above top-chord.

*Floor Beam Assembly*—Standard rolled I-beams are suitable for floor beams and brackets cantilever out under pedestrian walkways. Suspenders butt-weld onto beams, or, of desired, form stirrups at either end.

*Floors*—Open gratings welded to spandrels are likewise welded to stringers. The latter are carried by and welded to floor beams. Expan-

*(Continued on page 40)*

Top chord and suspenders showing the assembly of square members.



*Profile*

# Deane Waldo Malott

## Cornell's Sixth President

—Photoscience

Meet Mr. Malott! We are referring of course to Deane Waldo Malott, elected sixth president of Cornell University last winter by the Board of Trustees. Culminating an intensive two year search for the man best suited to guide the complex organization of Cornell, the Board of Trustees has found in Mr. Malott a capable and personable educator, businessman and admintor.

He officially took over the duties of President at his inauguration last September 19, having become acquainted with the campus during several visits he made last winter.

Mr. Malott assumes the presidency at a time of national and domestic crisis. Faced on one hand with the increased cost of University operations, the need for new buildings, and higher salaries, he must also contend with decreased income from the University's endowment fund and the possibility of diminished enrollments due to Selective Service requirements. In addition, there exists the tremendous task of gearing the University to national defense needs. However, President Malott has brought with him to Cornell a background of vast experience, which will greatly enhance his efforts to cope with these problems adequately.

A native of Abilene, Kansas, the fifty-three year old educator entered the University of Kansas in 1917, and soon distinguished himself as a scholar. He also acquired something of a reputation for his sense of humor and campus pranks, on one occasion having masqueraded as coed at a college dance. He has since maintained this reputation; as Chancellor of the University of Kansas he rode in a "nightshirt" car parade, and to raise money for the W. S. S. F., washed a student's car and served telephone duty at a sorority house, enthusiastically greeting somewhat bewildered dates. Faculty members were in for just about as much kidding: on the tenth aniversary of his inauguration as chancellor, they sponsored a formal dinner in his honor. In strode Mr. Malott—disguised as an old man, dressed in top hat and tails, with a white wig, horn rim glasses, and a false nose!

After receiving his bachelor's degree, he went on to the Harvard Business School, where he earned his master's in 1923. Offered an assistant deanship at Harvard, the young Kansan gave up his journalistic plans of editing a rural newspaper, and remained at Cambridge until 1929, when he became a vice-president of the Hawaiian Pineapple Company in Honolulu. He remained at this post for four years before making his decision to return to education, this time as an associate professor in the Harvard Business School, remarking that he would rather deal with people than pineapples.

The University of Kansas recognizing his preeminence in the fields of business and education, elected him chancellor in 1939, a position he has held until this year. At Kansas, Mr. Malott demonstrated his amazing ability to sell himself and the university to all, his open and friendly manner endearing him to students and faculty alike. Demonstrating his business ability, he improved the financial status of the university considerably; in his last year as chancellor, gifts and con-

tributions totalled some $1,223,000, in comparison with the figure of $113,000 received in 1938.

Dormitory facilities at Kansas increased tenfold under his guidance and a new scholarship residence hall system was undertaken, in which nearly 300 men and women received annual scholarships of $300. As Roy Roberts, president of the *Kansas City Star* observed, Kansas "really went to town" during the twelve years of Mr. Malott's administration.

**Need for Businessman**

All this is not too surprising in light of the fact that the modern university, though its main functions are to disseminate knowledge and to foster the mature solutions of human complexities, is basically a business organization in every sense of the word. It may be the only business which gives its "customers," the students, more than they can pay for; its "stockholders," by virtue of their diplomas, are the alumni, and instead of receiving dividends, they make contributions. Nevertheless, the extent to which the University will flourish depends for the most part upon the capabilities of its administration, headed, of course, by the President. To choose a scholar for the presidency as was customary years back, without any sound business or administrative training, would probably be disastrous today. The modern educator must combine ability with a sense of responsibility for the ideals of an educational institution. Mr. Malott has already offered ample proof that he meets these requirements.

A glance at the record will reveal that he is a former president of the National Association of State Universities, a former secretary-treasurer of the Association of American Universities, and is at present president of the Association of N. R. O. T. C. Colleges and Universities. Among his books are texts and general works on agricultural marketing and agricultural industries, public utility management, and corporation finance. His professional and honorary affiliations include Phi Beta Kappa, Sigma Delta Chi, Delta Sigma Rho, Beta Gamma Sigma, and Phi Delta Kappa fraternities.

In 1949, accompanied by Mrs. Malott, he went to Norway, to speak to university and research groups on the organization of research in the United States, and to India as a delegate to the Indian-American Conference, sponsored by the Indian Council on World Affairs, and the American Institute of Pacific Relations.

His business affiliations read like a stock-market report. At present he is a director of General Mills, Inc., and the Citizens Bank in Abilene, a trustee of the Midwest Research Institute and of the American Foundation for the Blind, and is a member of the Business Advisory Council of the United States Department of Commerce. To add to the list, he has also been elected to the board of Pitney-Bowes, Inc., the B. F. Goodrich Company, the Owens-Corning Fibreglas Corporation, and the First National Bank of Ithaca.

President Malott's educational philosophy is one that refuses to let high echelon administrative affairs interfere with his meeting as many of the students and faculty as possible. He believes that unless there are frequent contacts with the students there is no fun in running a university, and remarked that, "acting as task-master for the students is no function of the president's." He has already made an impromptu appearance at a Student Council meeting, taking the floor to give an informal address, and reads the Scriptures at the Sage Chapel services.

His quick wit and sense of humor have already become known to those fortunate enough to have met him since his arrival at Cornell. One finds him extremely cordial and cooperative, and his hearty laugh sets you right at home in his presence. There is every evidence that he will become warmly attached to both students and faculty.

In the short time he has been at Cornell, President Malott has become well acquainted with the numerous problems confronting the University. Foremost among these is that of maintaining a close and cordial relationship among students, faculty, alumni, parents, and townspeople. The lifeblood of a modern university is the support it receives from its friends. It is therefore essential that the President, as spokesman for the University, be extremely active at alumni functions from coast to coast, but at the same time be a familiar figure in the Ithaca community. Integral with this is the problem of coping with

*(Continued on page 32)*

**Governor Dewey greets Cornell's new president after the inauguration ceremony on the library slope.**

—*Stuckelman*

THE VITAL ELEMENT
OF ELECTRIC POWER

# SWITCHGEAR

By ROBERT L. SMITH, B.E.E. '45

Since man first witnessed a stroke of lightning, he has been fascinated by the phenomena of the electric arc. In the home, when an electric iron cord is pulled from the socket., an arc is created. An even more intense arc is present in the fuse box when a short circuit occurs in a household appliance. These familiar low intensity arcs are easily handled but the intensity of an arc depends on the voltage of the circuit, the amount of current flowing, and the means used to break the arc. If we were to attempt to handle a high voltage arc by the simple means used to extinguish the normal load current of an iron, the arc would reach tremendous destructive proportions.

**Installation using 230 kv, 10,000,000 kva General Electric impulse type oil circuit breaker.**

*—General Electric*

The nature of a short circuit may be understood easily through the use of a simple analogy. Imagine a dam backing a large reservoir of water equipped with several water-wheel turbines. The amount of water flowing through the turbines is analogous to the normal load current flowing through the circuit. The flow of water depends on the useful power load on the turbines just as the normal load current in a circuit depends on the power being delivered by the motors, lighting, and other circuit elements. Now, imagine that the dam bursts. A much larger amount of water flows which does no useful work and bears no relation to the useful power formerly delivered by the turbines. The flow of water is now related only to the amount of water in the reservoir and the size of the break in the dam. The bursting of the dam is insulation of the electric circuit and the resulting short circuit. The short circuit current has no relation to normal load current but is only related to the capacity of the power system to deliver to the short circuit current which does no useful work.

The performance of switchgear might be likened to the miraculous construction of a new dam a few yards downstream from the broken dam in time to stem the flood and prevent further damage. To do this miraculous job, switchgear must first successfully withstand the initial flood of current and then, in a few hundredths of a second, construct a new "dam" of insulation by opening the circuit.

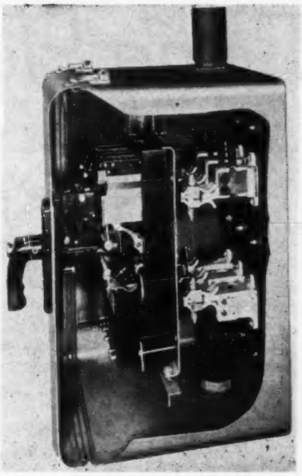
The amount of short circuit current which a circuit breaker must interrupt and the voltage of the circuit (analogous to the height of the dam) are the predominant factors determining the type of contacts, arc interrupters, and operating mechanisms of circuit breakers. The product of the current which must be interrupted and the voltage of the circuit, or kilovolts-amperes (kva), is the measure of the interrupting ability of a circuit breaker. This value varies from about 15,000 kva for small low voltage air circuit breakers to 10,000,000 kva for huge 230 kv impluse type oil circuit breakers.

**Determining Current**

The interrupting capacity required of a circuit breaker may be determined by a number of methods. One method generally used for the simpler systems is a rigorous calculation of this current. This is done by mathematically combining all the impedances of the generators and other circuit elements between the generators and the point of short circuit in the system into an equivalent impedance, assuming a generator voltage, and calculating what current would flow if a short circuit were present. However, in complex or extended a-c systems this would be a difficult and tedious process. For these systems, it is more practical to solve short circuit problems using a network analyser. This device consists of a number of impedances and generators built on a small scale which may be constructed by means of plugs to scale a complex power system to a resasonable size. A short circuit may be put on this scaled model of the impedances and sources of a power system and the resulting current measured. When a power company plans to make an expansion of any sort, a usual preliminary is to make an analyser study of the present system and the proposed expansion to determine how the added capacity will affect the system. A power company can then inform its customers what short circuit current can be delivered at any point in its system so the customers may select the proper switchgear.

**Breaker Function**

The actual function of a circuit breaker is to break the arc created when its contacts are opened. Since different parts of a system can deliver different amounts of short circuit current, several designs of circuit breakers are available. One type of circuit breaker breaks an arc by magnetically forcing the arc into a series of interleaved chutes, causing it to extinguish itself in air. Another type of air breaker blows the arc into a chimney by means of compressed air. A third type of circuit breaker depends on a physical arrangement which utilizes the pressure created by the arc between one set of contacts to force oil to flow between another pair of contacts to extinguish the arc. A fourth type of circuit breaker is the impluse breaker in which oil to extinguish the arc is forced by a mechanical piston between the parting contacts.



**Cutaway view of a 460 volt drawout air circuit breaker in enclosure for wall mounting.**

*—General Electric*

**Protective Relay**

A most important component of switchgear equipment is the protective relay, which detects the presence of an abnormal condition or fault and relays this information to the circuit breaker. The most common type of protective relay is the induction time-overcurrent relay. This relay, in which the current element operates similarly to the watthour meter, detects abnormally large currents in a circuit. In some cases it may be desirable to detect overcurrents in one direction only. In these cases, a "directional unit" is added to the overcurrent unit which prevents tripping unless the overcurrent is in the desired direction. Another type of relay detects over and undervoltages.

One method of detecting a fault

*(Continued on page 42)*

**ABOUT THE AUTHOR**

**The author graduated from Cornell in October, 1945 with a B. E. E. While at Cornell he was active in the Cayuga Student Residence, Cornell Corinthian Yacht Club, C. U. R. W., and the student branch of the A.I.E.E. After a short stint in the Pacific with the Navy as an Ensign, he joined the General Electric Company Test Program in April, 1947.**

**His test assignment included work with the Industrial Control, Power Circuit Breaker, Relay, Large Motor and Generator, and Steam Turbine Divisions. In 1948, he accepted a Requisition Engineering assignment in the Panel and Equipment Division of the Switchgear Divisions in Philadelphia. A year later, he became associated with the Switchgear Sales Division. The author has been a member of the Philadelphia Section of the Cornell Society of Engineers since his residence in the Philadelphia area.**

**Robert L. Smith**

# The Electronic Computer

## ITS AMAZING VERSATILITY
## SIMPLIFIES DIFFERENTIAL EQUATIONS

By JANICE BUTTON, EP '54

Anyone who has ever struggled with the solution of a differential equation or tried to predict the graphical form of a dependent variable for a certain set of initial conditions, would appreciate the ease and rapidity with which an electronic analogue computer can perform such mathematical operations. This type of instrument is capable of solving linear and non-linear differential equations (of an order restricted only by the amount of equipment available) and can untangle complicated problems which would be impossible to solve analytically.

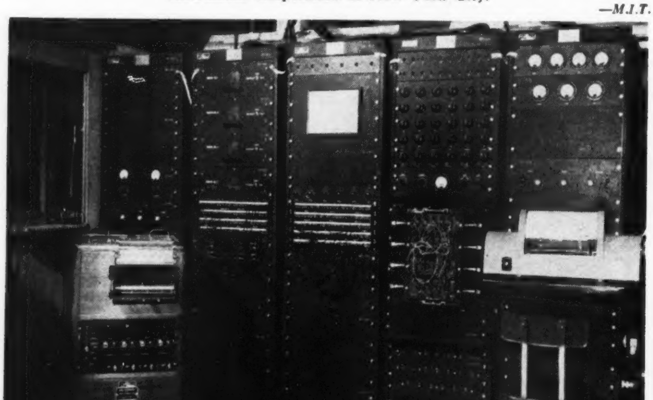
During the past ten years there has been much publicity about marvelous mechanical and electronic "brains"—giant machines that can determine instructions, calculate, and make decisions—machines that approach the human brain in ability to learn, remember, and reason. Computers of various types have found extensive use. It has become important to all people with technical interests to have a basic knowledge of such instruments.

**Type of Computers**

Computers may be classed as "analogue" or "digital," depending on the manner of representation of physical quantities. In an analogue computer, one physical system is used as a model for another, with continuously variable physical magnitudes being represented by electrical or mechanical quantities such as voltage or angular displacement. The digital computer expresses magnitudes as a number of digits, usually using the binary number system suited to the "off-on" operation of a mechanical relay or an electronic vacuum tube.* The standard desk calculating machine is an example of a simple non-automatic type of digital computer.

**Front view of the REAC electronic computer at M.I.T., manufactured by the Reeves Instrument Corporation of New York City.**

*—M.I.T.*



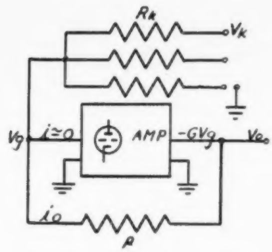
The accuracy of analogue computers is limited by the errors of the component devices, the total error (expressed as percentage error of full scale) increasing with the amount of equipment used (which is determined by the complexity of the problem). The digital computer, on the other hand, is accurate to a degree limited only by the number of significant figures used. However, both types have their advantages. While the analogue computer is accurate usually to only two or three significant figures (or about 1% error for values close to full scale), it is important in the solution of implicit equations (equations of the form $z=5x+y$ rather than the explicit form $x=(z-y)/5$, $x$ being the desired solution), which are oftentimes difficult to solve with the digital computer; and it is useful in presenting a solution in graphical form.

Computers may be further classified as electronic, mechanical, or electro-mechanical. Electronic devices are, as a rule, much faster than mechanical devices, and most mechanical types of computers include some electronic components (e.g., the Rockefeller Differential Analyzer at M. I. T.).

**Feedback**

The use of "feedback" signal is a basic principle of analogue computer design. In electronic instruments, feedback from the output of an amplifier to the grid input with the proper adjustment of input and output-to-input impedances makes possible the summation, integration, or differentiation

*See Cornell Engineer, Feb. 1951



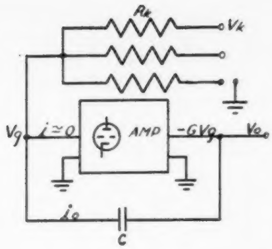

$$V_o = -GV_g$$

$$i_o = \frac{(V_o - V_g)}{R} = -\Sigma \frac{(V_k - V_g)}{R_k}$$

$$V_o + \frac{V_o}{G} = -\Sigma \frac{(V_k + \frac{V_o}{G})}{R_k} R$$

$$\text{OR} \quad V_o = -\Sigma \frac{V_k R}{R_k}$$

1a. SUMMER




$$V_o \simeq -GV_g$$

$$C(V_o - V_g) = Q = \int i_o dt = \int -\Sigma \frac{(V_k - V_g)}{R_k} dt$$

$$V_o + \frac{V_o}{G} = -\int \Sigma \frac{(V_k + \frac{V_o}{G})}{CR_k} dt + V_{IC}$$

$$\text{OR} \quad V_o = -\int \Sigma \frac{V_k}{CR_k} dt + V_{IC}$$

1b. INTEGRATOR

**Figure 1. (a) An amplifier circuit used for the purposes of summing. (b) An amplifier circuit used for integrating.**

of voltages, as will be seen below. Feedback in the form of an "error signal" is useful in other kinds of electronic circuits, as for example a pulsed attenuator circuit used for voltage multiplication or division. Also, error signal feedback is a characteristic feature of the servo-mechanism, which may be defined as an energy-transforming device whose final output is a controlled function of the output and input. Servos make possible the use of feedback in mechanical systems and serve as control elements in various types of bridge circuits.

The solution of equations is accomplished by the use of feedback connections. An error signal (z/A), the output of some electronic device, may be highly amplified (by factor A) and fed back (as z) to the electronic instrument, which performs operations indicated by a function f(x,y,z) to make possible the solution for z=g(x,y) from the implicit function f(x,y,z) =O=output z/A; or a feedback loop may be used without amplifiction to obtain the solution of the equation f(x,y,z)=z—the desired quantity z being taken from the amplifier output in the first case and from the output of the operating components (summers, integrators, etc.) in the second case. This implicit function technique makes it possible to perform the operation of subtraction by addition, division by multiplication, differentiation by integration, and extraction of square roots by squaring. It is useful in electro-mechanical as well as electronic circuits.

### Computer Components

Amplifiers of high gain are essential components of electronic analogue computers. Provided with a resistor feedback, an amplifier can be used to sum up input voltages, the negative feedback signal keeping the grid voltage very small. Since there is practically no grid current, the current in the feedback loop equals the sum of the input currents; therefore the voltage drop in the feedback loop is proportional to the sum of the currents in the input resistors, each current being proportional to the applied voltage. Similarly, with a capacitor instead of a resistor used in the feedback loop, the current in the loop will again be equivalent to the input currents, and it can be shown that the voltage output of the amplifier will be the integral with respect to time of the sum of the input voltages. (See figure 1 for explanation. For more detailed treatment, refer to *Electronic Instruments*, Vol. 21, M. I. T. Radiation Laboratory Series.) A modification of these devices with a resistor and capacitor in parallel used for feedback is sometimes desirable. For purposes of differentiation, the input resistor and feedback capacitor can be interchanged; however, this arrangement is not as satisfactory as the integrating device because of the magnification of electrical noise and also the possibility of unstable oscillations in the resistor feedback loop. An alternative method of differentiating involves the use of an inductance coil in the feedback loop, but this does not give good results (nor does integration by inductance input) because of the resistance of the inductance coil and saturation and hysteresis effect (in any coil except the air-core type).

Multiplication of a voltage by a constant less than unity is achieved by the use of a potentiometer (a wire coil, one end of which is grounded, the attenuated voltage being taken off an arm, whose position between ground and the other end of the coil—to which the voltage is applied—is determined by the desired constant). Increase of a voltage by a certain factor is accomplished by choosing the appropriate input resistor in a summing or integrating amplifier. (Non-linear potentiometers and sometimes loaded or ganged poten-

**Symbols Used:**

**Figure 1:**
- $V_k$ voltage input to amplifier
- $R_k$ input resistance
- $i_o$ current in feedback loop
- $V_g$ grid voltage
- G gain of amplifier
- $C_o$ capacitance in feedback loop
- R resistance in feedback loop
- IC initial condition

**Figure 2:**
- θ angle of rotation of servo shaft
- $\theta_m$ maximum angle of rotation = 200 degrees, equivalent to 100 volts input
- $V_1$ voltage input to servo controlling position of servo shaft
- $V_2$ voltage input to potentiometer
- CT center tap of potentiometer

**Figure 3:**
- n independent variable in given equation
- $y(o)$ value of y when n = O
- $P_1$ potentiometer #1
- $C_1$ correction for loading of potentiometer by one-gain input resistor of amplifier
- $C_{P_7}$ correction for loading by potentiometer #7

tiometers may be used to approximate non-linear functions.)

Multiplication and division of two voltages can be accomplished by such devices as synchros, pulsed attenuator circuits, bridge or Ohm's Law dividers, but probably the most common method is one involving a mechanical instrument—a servo used with a helical linear potentiometer. The position of the pick-off arm on the potentiometer is controlled by the servo shaft. If the center tap of the potentiometer (corresponding to the zero position of the servo shaft) is grounded and one of the voltages and its negative are fed into the ends of the potentiometer with the other voltage used as the servo input, the voltage taken off the arm of the potentiometer will be proportional to the product of the two input voltages. Division is accomplished by changing potentiometer connections and making use of two summing amplifiers. (See figure 2.)

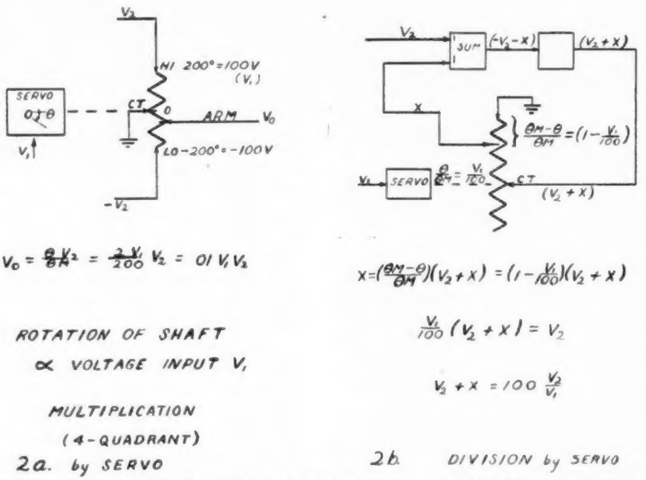



**Figure 2. Typical mechanism used in the REAC computer. (a) Multiplier. (b) Divider. G, gain of amplifier, is very large, thus Vo/G is neglected.**

Another useful component of electronic analogue computers is the resolver, a device whose output voltage is a sinusoidal function of a voltage applied to a servo. It consists essentially of two mutually perpendicular linear coils which set up perpendicular magnetic fields (of magnitude determined by voltage inputs A and B to coils) with a secondary set of perpendicular coils whose angular position relative to the first is determined by the input voltage to the servo. The resolver has two outputs—one equal to $(A \cos \Theta - B \sin \Theta)$ and the other to $(A \sin \Theta + B \cos \Theta)$. By the appropriate feedback arrangement between one of the secondary coil outputs and one of the field coil inputs, the tangent function of the servo input voltage can also be produced.

Before proceeding further, it is interesting to compare the mechanical counterparts of these electronic devices. There are many possible ways of performing addition and subtraction operations mechanically—by levers, gears, pulleys, etc., but the differential gear unit, similar to the automobile differential, is the most satisfactory. The most common integrating device is the ball and disk integrator (See figure 3.), which may be converted to a differentiator by a sort of error signal feedback. Gyroscopes and tachometers are also used for integrating or differentiating. Multiplication by a constant is easily achieved by choosing the right combination of gear ratios, but mechanical multiplication of two functions is somewhat more difficult. The sum of two integrations in accordance with the relationship

$$xy = \int x\,dy + \int y\,dx$$

is the method used in the electromechanical Rockefeller (Bush and Caldwell) Differential Analyzer at M. I. T. Logarithmic cams, tape wheels, and similar triangles are some of the other means of mechanical multiplication. The production of trigonometric functions is possible with various kinds of devices, most of which utilize the principle of simple harmonic motion.

Mechanical computers are not limited, as are the electronic computers, to equations whose independent variable can be represented by time; i.e., differentiation and intergration can be performed with respect to variables other than time. However, the nature of some of the mechanical devices presents difficult problems; friction, slippage, and backlash can be made negligible only by having parts precision-made to very fine tolerances. The Rockefeller Differential Analyzer is accurate to one part in ten thousand or up to six digits.

### Typical Analogue Computer

The "REAC" at M. I. T., an instrument manufactured by the Reeves Instrument Corp. of New York City, is typical of the electronic analogue type of computer. It has twenty d-c amplifiers, which include seven integrators (capacitor feedback), six inverters and seven summers (resistor feedback). The integrators and summers each have seven inputs with gains of 1, 4, and 10, corresponding to input resistors of 1 megohm, 250 kilohms, and 100 kilohms (the feedback resistor having a value of 1 megohm; the feedback capacitor, 1 microfarad). The inverters differ from the summers only in that all inputs have a gain of one; they are usually included in the term "summers." Twenty-four linear ten-turn potentiometers, each of 30 kilohm resistance, are available.

The two outside panels of the REAC (see picture) are the power supply for rectifiers and servos and for amplifiers, etc. The second panel from the left contains four servos, each of which (except for Servo #1) controls three potentiometers. Also in the second panel are several resolvers, with modulating and demodulating equipment necessary for converting the d.c. signals used with the amplifiers to a 1000-cycle alternating signal for the resolvers, and vice-versa. The middle panel

has six extra "passive-network" potentiometers and serves to provide inter-console connections to mechanical relays and other occasionally used devices (such as limiters) not discussed here.

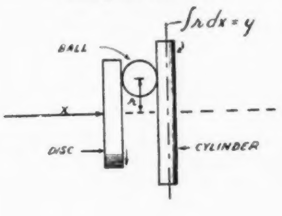
The main panel (second from right), from which the twenty-four potentiometers are controlled and the initial condition voltages of the integrating amplifiers regulated, has a rectangular section into which a "pre-patch" board is fitted. Used for convenient set-up of a circuit previous to the actual use of the REAC, the patch board has many tiny jacks which fit into sockets permanently connected to the various components of the instrument. It can be plugged into the REAC in a matter of seconds, making it possible for several problems, each set up on its own patch board, to be worked on alternately.

Also on the main panel is a voltmeter, which can be connected to any of the amplifiers, and warning lights to indicate overloading of individual amplifiers (which occurs usually around 100 volts). One useful feature of the REAC is a means of holding all voltages fixed at any point during a run simply by turning the operating switch to the "hold" position.

### Planning the Circuit

The procedure used in preparing a problem is first to set up a diagram of the circuit (a sort of schematic block diagram showing the connections between amplifiers, potentiometers and servos—see figure 4), a necessary step before the proper connections can be made on the patch board. This is the difficult part of the problem, and

**Figure 3 (a). Mechanical type integrator, used on such instruments as bombsights during the last war.**




3a. MECH. BALL AND DISC INTEGRATOR

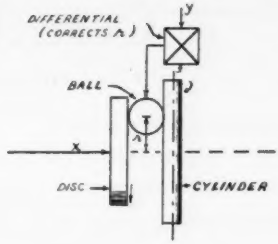
sometimes much ingenuity is required to find the most efficient arrangement of equipment to give a solution with minimum error or to make possible the solution of an equation which is so complex as to make necessary the use of all available equipment.

The usual method of planning a circuit is to start with the highest order derivative in the given equation and, by putting a voltage signal corresponding to this mathematical quantity through a succession of integrators, to reduce it to the variable itself. The given equation can be expressed as a sum of lower-order derivatives, with constant or variable coefficients, equal to the highest order derivative. By feedback of outputs from the appropriate amplifiers with potentiometers or servos serving to multiply (or divide) each voltage by a constant or a variable function, all voltages representing the component terms of the equation defining the higher order derivative are summed up as inputs to the first integrator.

As can be seen from figure 1, the output of any of the amplifiers is negative in sign with respect to the input, as required for the negative feedback. Thus summers can be used to change the sign of a variable input—hence the name "inverter" for the one-gain summer. The change of sign accompanying an integration must be taken into account in the circuit set-up.

Representation of a constant or a linear function of time is accomplished by connecting a positive or negative 100 volt source on the patch board (on which all connections between amplifiers, potentiometers, servos, etc.—everything except resolvers, modulators, and inter-console equipment — are made) to a potentiometer and then to a summer or integrator. (See figure 4.) Initial condition voltages are applied to integrating amplifiers by potentiometers connected to a 100 volt source and controlled from the main panel of the REAC.

Time is the independent variable of the REAC circuit operations. The time interval measured from the instant of turning on the operating switch (above the patch board) to some particular point in




ERROR $dr = g(dy - \frac{\lambda}{a}dx) = 0$

$dy$ SHOULD $= \frac{\lambda}{a}dx$

OR $\frac{\lambda}{a} = \frac{dy}{dx}$

3b. DIFFERENTIATOR

**Figure 3 (b). Mechanical type differentiator by correction.**

a run corresponds to a certain interval in which time or some other linearly increasing independent variable of the physical system has increased from zero to a particular value. It is not always convenient to have one-to-one correspondence between REAC time and the physical variable; for example, a two-minute run may represent an interval of two hours in the physical system, one second of REAC time representing sixty seconds of physical time. The choice of time scale is limited to some extent by the accuracy of the servos, whose angular velocity should not exceed ten degrees a second, since above that velocity time lag in servo response causes significant error.

### Further Considerations

In analogue computers, as in any analogue device, a scale has to be decided upon in which so many units of a quantity in the model system are set equal to so many units of the corresponding quantity in the original system. In the sample problem (See figure 4.) the author chose to indicate the number of volts equal to one unit of the physical variable. The scale is rarely the same in every part of such a circuit, since it is oftentimes necessary to cut down a voltage to avoid overloading an amplifier or to increase it to give more accuracy. Also, the time scale must be taken into con-

*(Continued on page 28)*

# Cornell Society of Engineers

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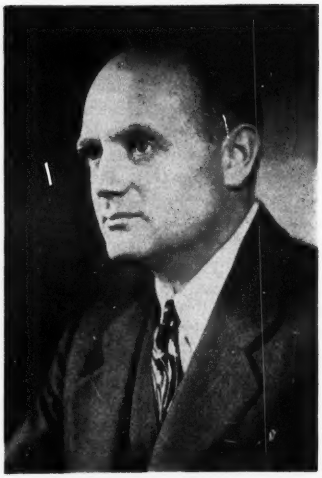

**Frederic C. Wood**

*"The objects of this Society are to promote the welfare of the College of Engineering at Cornell University, its graduates and former students and to establish closer relationship between the college and the alumni."*

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## President's Message

The word engineer is a pretty wide one. Even eliminating the engineers who stay within the original meaning of the word and actually run engines, we still are in a broad field.

In the last 100 years we have proceeded with our customary job of classification. First, all engineers were mixed up with the engines of war—were connected with the military. When civilian purposes were found for some of their endeavors we coined the title civil engineer. As machinery became a more and more important part of our economy—as steam power made itself felt, we fitted out the title of mechanical engineer. With the development of electricity not so long ago, the electrical engineer came to the fore. With the huge strides of industrial chemistry came the chemical engineer.

Within these broader circles we have gone even further. Automotive engineers, Diesel engineers, maintenance engineers, aeronautical engineers, highway engineers, structural engineers, mining engineers, illuminating engineers, hydraulic engineers, sanitary engineers, agricultural engineers, bridge engineers, combustion engineers, fire protection engineers, geological engineers, heat-power engineers, petroleum engineers, radio engineers, refrigeration engineers, telephone engineers—and there are a multitude of others.

In reality there are almost as many different kinds of engineers as there are people in engineering. Think of all the men you know in this field and it is hard to think of any two that have identical work. It is little wonder that we confuse the undergraduates.

To go further there is a large group of people trained in engineering who are somewhat remote from direct engineering application but who are nevertheless doing important engineering jobs. They may be in the industrial or labor relations, in law, in public relations, in insurance, in retailing, wholesaling or warehousing, in systems or methods work.

It is such a variety of engineers who make up this Society. Another good reason for being a member—to get the chance to broaden yourself by meeting and knowing and talking with technically trained Cornell engineers, who hold such an assortment of important jobs in engineering and in our commerce and industry. Come out and see.

FRED C. WOOD

# *Alumni News*

**Thomas S. Ramsdell, M.E. '03,** textile engineer, is a consultant to Whitin Machine Works in Whitinsville, Mass. The firm, builders of textile machinery, is now developing several pieces of equipment under his patents. He lives on Stockbridge Rd., Great Barrington, Mass.

**Allan H. Candee, M.E. '06,** engineer with the Gleason Works in Rochester, was made a fellow of the American Society of Mechanical Engineers in May and elected president of the Rochester Engineering Society in June. His address is 404 Hillside Ave., Rochester 10.

**Samuel H. Woods, M.E. '06,** retired September 29, 1950 from full-time civil service with the Ordnance Corps, Department of the Army, but is still serving as consultant on problems concerning mobility of military vehicles. Most of his service was at Aberdeen Proving Ground, which is still his home station. He lives on RD 2, Aberdeen, Md.

**James W. Parker, '08,** president of Detroit Edison Co., recently turned over his position to **Walker L. Cisler '22.** Both are graduates of the College of Engineering. Parker was a trustee of the University for several years while Cisler is now serving on the Board of Trustees.

Active as a technical adviser to the War Production Board and the War Manpower Commission during World War II, Parker served more recently as chairman of the industrial advisory group of the Atomic Energy Commission. Cisler has been chief consultant on electric power for the U.S. Economic Cooperation Administration.

**Lieutenant Colonel Knibloe P. Royce M.E. '16,** was recalled April 12 for twenty months of active duty in the Air Force Reserve. He is presently assigned as Chief Production Branch Plans and Operations Procurement division, Hq. Air Materiel command, Wright Patterson Air Force Base, Dayton, O.

**Frank W. Pierce, M.E. '16,** a director of Standard Oil Co. (N.J.) received for his company this year's award of the House Magazine Institute in recognition of its program of communications with employees, stockholders, governments, and public. At the annual conference of the institute in New York City, Pierce described his company's methods of promoting better understanding, saying that Jersey Standard publishes eighty-five different magazines and newspapers in twenty-four countries and in thirteen languages. Pierce's office is at 30 Rockefeller Plaza, New York City 20.

**Robert D. Abbott, B.Chem. '17,** of R. D. Abbott Co., in development, application and sale of materials for the rubber industry, is chairman this year of the Los Angeles Rubber Group. He lives at 2505 North Cameron Ave., Covina, Cal.

**Charles H. Brumbaugh, M.E. '23, '24,** was recently transferred by the Barber-Greene Co. to 1700 Commerce Street, Dallas, Texas, where he is area manager of the southwestern district. The company manufactures asphalt paving equipment, ditchers, conveyors, and bucket loaders.

**Harold B. Maynard, M.E. '23,** founder and president of Methods Engineering Council, consultants in industrial management, addressed the Detroit chapter of the Society for the Advancement of Management on Methods-Time Measurement. He also attended the Ninth International Management Congress in Brussels July 5-11. He is vice-president and U.S. representative of the executive committee of the International Committee of Scientific Management, sponsors of the Congress.

**Robert L. Fearnside, M.E. '23, '24,** is now vice-president of the Mutual Federal Savings & Loan Association of Bowling Green, Ohio. He has been on the board of the bank since 1937 and is a member of the executive committee.

**William F. Bernart, M.E. '24,** of Ponus Ridge, New Canaan, Connecticut, executive vice-president of Pitney-Bowes, Inc., Stamford, has been elected to the company's board of directors.

**Donald W. Champlin, '24,** formerly general manager of the equipment manufacturing division of Continental Can Co., has been named a vice-president of the M. W. Kellogg Co., refinery and chemical engineers of Jersey City and New York, with responsibility for all of the company's manufacturing activities in the field of fabricated metal equipment for petroleum refining, chemical and electrical utility firms. Before joining Continental Can in 1947, he was vice-president and general manager of Defiance Machine Works, manufacturers of machine tools in Defiance, Ohio.

**August F. Jones, E.E. '24, '25,** is in charge of surplus disposal at the Federal Telephone & Radio Corp., Clifton, N. J. He just spent an interesting year in Greece with his wife and daughter and lives at 77 Tall Oaks Drive, Summit, N. J.

**L. Irving Woolson, M.E. '26,** operating manager of De Soto Division of Chrysler Corporation since 1948, is now vice-president and director of the corporation. He has been with Chrysler for twenty-two years. His address is 715 Glengary, Birmingham, Mich.

*(Continued on page 44)*

# Techni-Briefs

## Portable TV Transmitter

A new portable television camera has been developed by R. C. A. laboratories. Weighing only 53 pounds, the back-pack station is planning function with its own battery supply of power. It has a range of about one mile, and because of its ease of transportation, numerous applications, such as news coverage and remote industrial viewing and control, are foreseen.

The new transmitter operates in conjunction with a control station. Signals corresponding to the scene being televised are transmitted to the central point on an ultra-high frequency with a power of two watts. In addition to acting as monitor, the control station sends out a stream of pulses which stabilize the camera and can be used to issue vocal instructions to the operator of the camera.

The back-pack is carried knapsack fashion. Two small antennae extending from the top of the pack serve to transmit the picture signal to the central station and receive voice and control signals. The camera is an adaption of the R. C. A. industrial TV camera using a Vidicon tube. As an added feature, the camera includes a miniature kinescope picture tube which serves as a view finder for the cameraman.

The equipment includes 42 pencil-type tubes which, with their associated cricuits, provide all synchronizing frequencies for a standard 525-line, 30-frame, interlocked TV picture. Included in the unit are a battery-power supply, which lasts one and one half hours, deflecting circuits, amplifiers, and a radio receiver. The radio-camera-man's voice is picked up by a small microphone built into the camera case, and is transmitted by an ingenious electric circuit which adds voice signals to the picture signals.

**The new backpack television transmitter station. Notice the miniature camera using the Vidicon tube.**

*—R.C.A.*

## Canadian Power

In 1950, Canadian hydroelectric power made the greatest single advance in its history with an addition of over 1,000,000 h.p. A large part of this increase in power supply is located in Ontario and represents a culmination of the huge post-war construction program of the Hydroelectric Power Commission of Ontario, particularly the near completion of the Des Joachims Plant on the Ontario River. Other new installactions during the year were well distributed across Canada.

Hydroelectric developments and extensions now under active construction total about 1,000,000 h.p. with an additional 1,500,000 under preliminary construction or definitely planned. Added to Canada's 12,655,000 h.p. already in operation, these additions will make Canada one of the largest producers of hydroelectric power in the world, and represent attractive site for industry.

## High Speed Bearings

Designers of automotive engine bearings must, in effect, strike a balance between strength and softness, a General Motors Research engineer reports to the American Society of Mechanical Engineers. The softness, which engineers describe as embedability, permits microscopic abrasive particles to be absorbed by bearing surfaces without damage to the shaft or its bearing. However, increasing embedability reduces a bearing's fatigue strength and durability.

Whenever bearings are subjected to intermittent loading, such as they are in an auto engine, fatigue strength is preferred over embedability. For this reason, engine parts are thoroughly cleaned before assembly and placement in the

*(Continued on page 42)*

# PROMINENT ENGINEERS

Chad

## Chad Graham, MetE '52

Chad Graham is one of that rare species of engineer who can combine as time-consuming a job as the editorship of the *Cornell Daily Sun* with the demanding work of one of Cornell's most rigorous courses. Through prominent in various campus activities, Chad has attained the rank of fifth place in his Metallurgical Engineering class of thirty-seven. He is corresponding secretary of Tau Beta Pi and vice-president of Pros Ops, ChemE and MetE honorary.

Chad came to the engineering school from Oakland High School in Dayton, Ohio. A National Scholar, has been on Dean's List several times and has represented his school on the Student Engineering Council. He would like it clearly understood that he is in the MetE, not the ChemE school; he seems very happy to have avoided the notorious Unit Ops course for which the latter school is so well known.

The position of editor-in-chief of the SUN was one of Chad's biggest jobs last year. His editorials were remarkable for their perspicacity and were one of the outstanding features of the paper. His by-line was very familiar to most Cornellians. In recognition of Chad's ability and accomplishments, he was made a member of Sigma Delta Chi, the journalism honorary.

Further refuting the idea that engineers do nothing but eat, sleep, and study, Chad has been prominent in the work of the Student Council and has been active on Straight Committees. He is now a member of the Straight Board of Managers. Chad is associated with Quill and Dagger, senior men's activities honorary, and with Theta Xi fraternity. This year he served as a Frosh Camp counselor, which, among other things, gave him a chance to exercise his talents on the guitar.

His Cornell life has not been all work and no play, though even in social matters he can't get away from the *Sun*. His engagement to Allison Bliss '52, editor of the women's page of the *Sun*, was announced recently.

Chad was very enthusiastic about his summer work at Battelle Memorial Institute in Columbus, Ohio. In connection with Atomic Energy Commission projects, he had an opportunity to do some very interesting work on X-ray diffraction. He is especially interested in crystallography and expects to apply for a Fulbright fellowship to study at the University of Birmingham in England. As an alternative he contemplates graduate work at M. I. T.—and then the start of what promises to be a very successful career in the field of metallurgy.

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## Pete Rose, ME '52

When Pete Rose entered Cornell as a mechanical engineer in 1947, he probably had less doubt about his future than most of his classmates. He had already received a taste of engineering at Brooklyn Technical High School where, as a student in the Aeronautics Course, the intricacies of aero engineering were first introduced to him. Pete enjoyed the subject from the start and when he graduated in 1945 decided to continue his education in college. However, Uncle Sam had other plans for him and it wasn't long before he was a member of the Army Air Force. Pete spent most of his two year hitch as flight engineer on a C-54 and needless to say picked up quite a bit of invaluable experience. When he was discharged in 1947 he was convinced of his future in aeronautical engineering.

Success smiled upon Pete almost from the moment he entered Cornell. In his freshman year he not only established himself as one of the top men in his class by virtue of his scholastic achievements, but also devoted much of his time to extracurricular work. Being an avid athlete he took part in freshman swimming and soccer, and has since played three years on the varsity soccer team, winning three letters

*(Continued on page 40)*

Pete

# News of the College

## Radio Scientists Meet

Approximately one hundred and fifty scientists from the United States and several foreign countries convened at Cornell's School of Electrical Engineering on October 8, for a three day joint meeting of the International Scientific Radio Union (U. S. A. National Committee) and the Institute of Radio Engineers (Professional Group on Antennas and Propagation).

Dr. Charles R. Burrows, chairman of the U. S. A. National Committee, and director of the School of Electrical Engineering, was general chairman and host for the gathering. He was instrumental in bringing the scientific group to the campus since the meetings were formerly held semi-annually in Washington, D. C.

Approximately 200 visitors attended the sessions, some coming from as far away as Alaska and New Zealand. Others listed as coming from American laboratories were actually European scientists working on contracts in this country. The delegates represented colleges and universities and various government laboratories.

Topics discussed at the technical sessions included "Experimental Determination of Rates of Decay of Meteoric Echoes as Functions of Wave Frequency and Height," "Solar Noise Storms and Plasma Oscillations," and "Validity of the Substitution Principles of Bolameter Power Measurements". Highlighted were discussions centering on the latest discoveries and technical developments in the field of wave propagation as related to the sun, stars, and upper atmosphere.

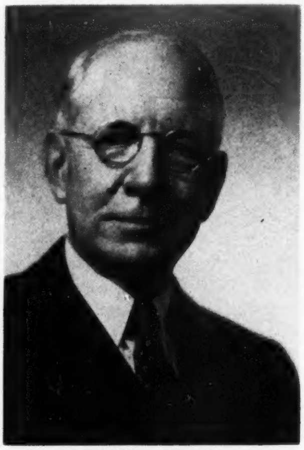
The International Scientific Radio Union is one of the several world scientific unions organized in 1919. It has its headquarters in Brussels, Belgium, and is supported by grants from various governments, the United Nations Educational, Scientific, and Cultural Organization (UNESCO), plus contributions of voluntary services from its members.

## Plastics Laboratory Given

Cornell University has announced the establishment of a laboratory devoted specifically to rubber and plastics. The unit is named for Dr. William C. Geer, A. B. '02, of Ithaca, one of the country's foremost rubber chemists, who donated equipment from his private laboratory, funds for additional apparatus and a valuable library on rubber toward the project.

President Deane W. Malott described the laboratory as one of the first of its kind among American colleges and universities. He said it was hoped the center would be able to develop new information about rubber and plastics for the benefit of industry, the government and the general public.

The center, which will be known as the William C. Geer Laboratory of Rubber and Plastics, has been formed in the School of Chemical and Metallurgical Engineering directed by Dr. Fred H. Rhodes. Prof. C. C. Winding, a specialist in rubber



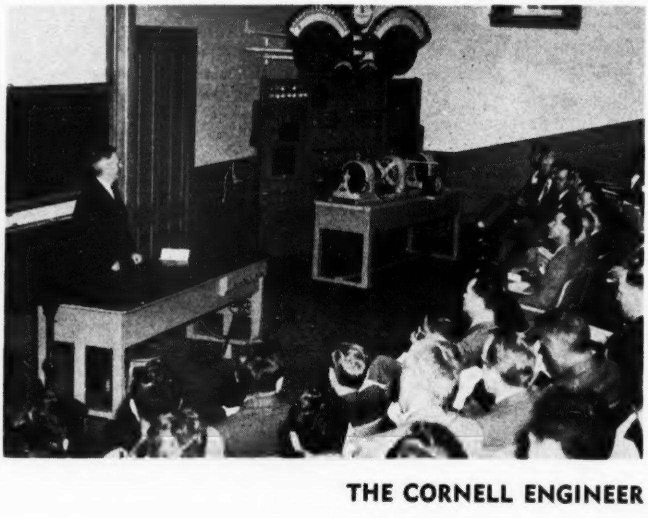
**Dr. William C. Geer**

and plastic chemistry, will be in active charge.

Research is expected to concentrate largely on problems of synthetic rubbers. Similar work has

**Dean S. C. Hollister addresses a meeting of the International Scientific Radio Union in the newly redecorated Franklin Lecture room.**

—*Photoscience*



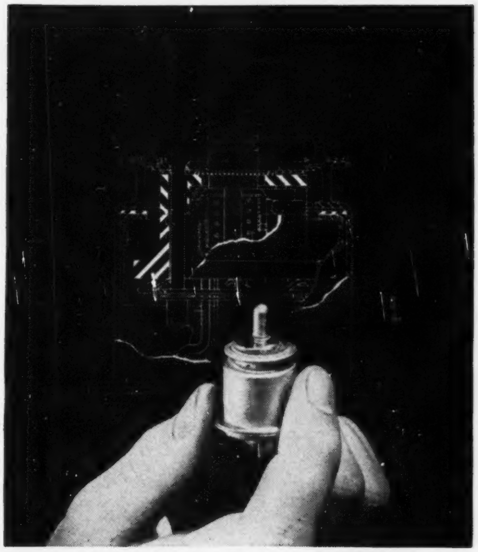
# THIS MIDGET TUBE WAS A MIGHTY CHALLENGE

It had Bell Telephone engineers scratching their heads.

A new kind of electron tube was needed for coast-to-coast *Radio Relay*. It had to amplify a wide band of super-high-frequency signals. It had to relay them, without distortion, every thirty miles across the country.

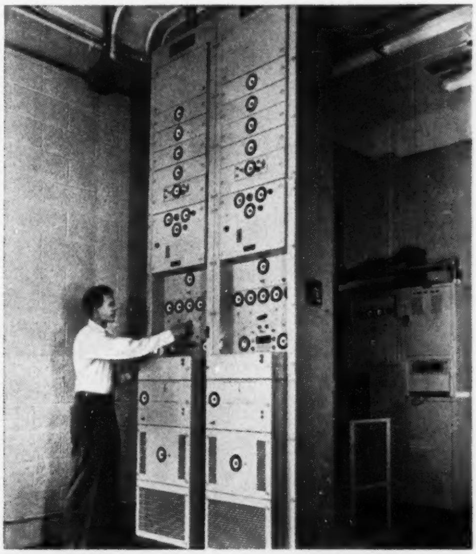
That meant splitting hairs. For the working elements of the new tube would have to be five times closer together than in any other tube. And that's mighty close — 6/10 mil between grid and cathode; grid wires 1/3 mil thick, and wound a thousand to an inch.

What's more, the tube had to be designed for assembly-line production, then installed and maintained, and its performance on the job analyzed.



The walnut-size midget was developed and the first samples were made by scientists in the Bell Telephone Laboratories. It was a joint project, involving electrical, mechanical and chemical engineers, and skilled ceramic, metallurgical and other technicians.

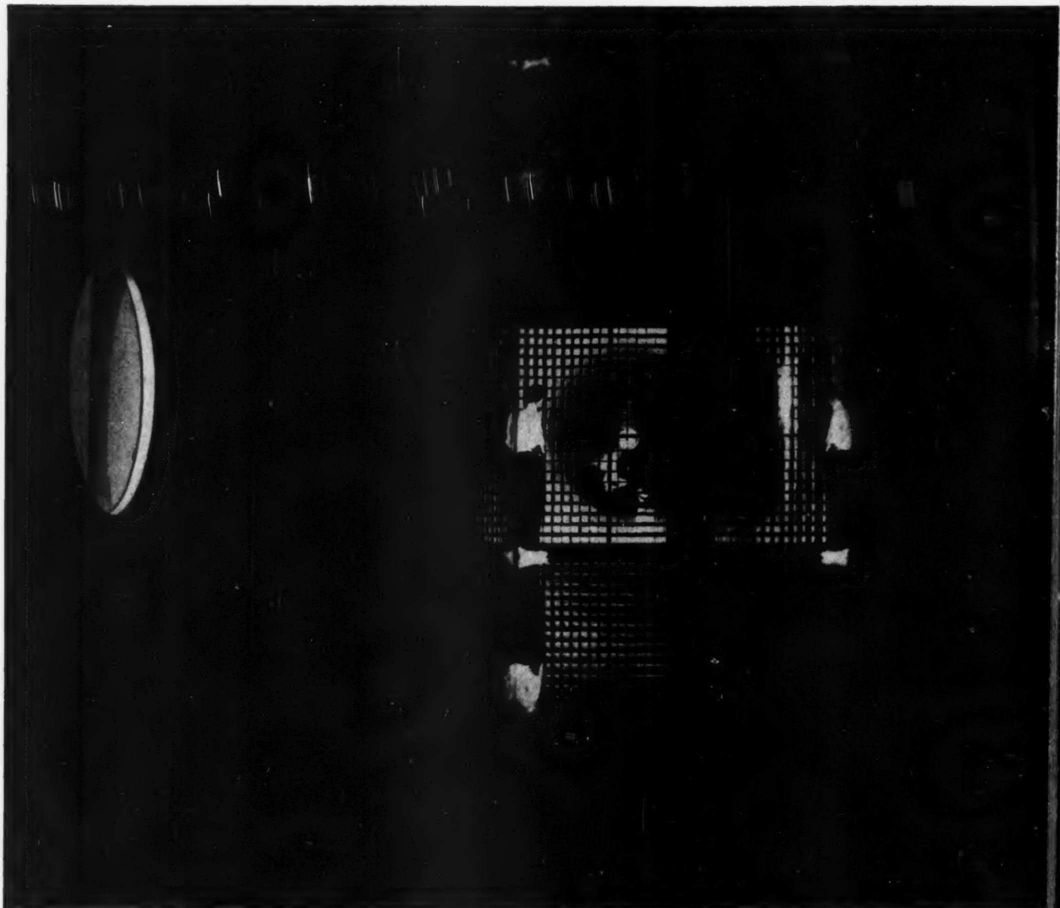
Quantity production of the (416A) tube was a job for Western Electric, the manufacturing unit of the Bell System. Work had to be done under microscopes. Western's engineers designed new equipment, worked out details of assembly, devised ways to develop skillful workers, simplify operations, keep assembly areas surgically clean.



Engineers in the operating companies and A. T. & T.'s Long Lines Department continually study the performance of the "Mighty Midget" as it plays its part in speeding telephone calls and television programs across the nation. From their studies will come more challenging problems for—and more solutions from—Bell System engineers.

BELL TELEPHONE SYSTEM

# Only STEEL can do so many jobs



**CAVE OF THE WINDS.** This largest "supersonic" wind tunnel in the world—at the National Advisory Committee for Aeronautics, Lewis Laboratory, Cleveland—is capable of providing air velocities up to twice the speed of sound for aeronautical research. The tunnel's testing chamber measures 8 by 6 feet, and has flexible walls of highly-polished U·S·S Stainless Steel plates, specially made by U.S. Steel for this vital defense project.

**NEW WAY TO GATHER GOOBERS.** This new peanut combine threshes along the row where the peanuts are grown, gathers up nut-laden vines, picks them clean, and deposits the mulch to condition the soil for the next crop. In tests, it has reduced harvesting man-hours per acre from 30 to 4, lets two men do the work of 12, saves $40 an acre. By supplying steel for such equipment, U.S. Steel helps build a more productive America.

AMERICAN BRIDGE COMPANY • AMERICAN STEEL & WIRE COMPANY and CYCLONE FENCE DIVISION • COLUMBIA STEEL COMPANY • CONSOLIDATED WESTERN
TENNESSEE COAL, IRON & RAILROAD COMPANY • UNION SUPPLY COMPANY • UNITED STATES STEEL COMPANY • UNITED STATES STEEL EXPORT COMPANY

been under way in the school since World War II.

The laboratory will be formally opened next month. In addition to its use by members of the school's staff, it will be devoted to group research projects required of all students in the final year of the school's five-year undergraduate curriculum. Ultimately, Professor Winding said, it is expected to be employed in some advanced laboratory courses for graduate students.

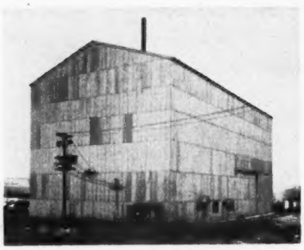
The equipment given by Dr. Geer forms a complete unit for producing, vulcanizing and testing rubbers. Professor Winding said the laboratory, when finally equipped, will be able to start with raw materials, turn out finished products in synthetic rubber and and plastics and subject them to various tests.

## New High Voltage Lab

Construction has begun on a new High Voltage Laboratory to replace the center which was destroyed by fire in February of 1948.

The new laboratory is being erected on the site of the former building on Mitchell Street Extension, adjoining Vetsburg, and like its predecessor will be given over to teaching and research in the field of high voltage phenomena.

The rectangluar building, designed by the Department of Buildings and Grounds, will be done in cinder block and corrugated Transite and will cover a plot measuring 70 by 122 feet. It will contain offices, a shop and darkroom, control spaces, a large bay for the high-voltage work, and a 20-ton travelling crane for handling heavy equipment. Railroad tracks will run onto the floor to enable shipments to be unloaded directly on the site.



**The high-voltage laboratory before its destruction in 1948.**
—*Photoscience*

A large quanity of equipment, obtained through gifts from industrial concerns and by purchases of war surplus material, is already on hand. The new laboratory will also use some equipment salvaged from the fire at the old building.

Initial building operations will be on the office section to permit the staff to begin work before the structure is actually completed. Steel work is expected to go up next spring, and the building is scheduled to be ready for occupancy by next fall.

Completion of the laboratory will enable Cornell to resume a place as one of the leading university centers for work with high voltages.

**Raging flames left the old high-voltage laboratory this twisted pile of wreckage, a loss of $1,000,000.**
—*Photoscience*

## New Fellowships

Fellowships for graduate study in science and engineering at Cornell University were awarded to seven students by the Cornell Aeronautical Laboratory, Inc., at Buffalo, a subsidiary corporation of the University.

Six of the fellowships are named for "research associates" of the laboratory, industrial firms which have contributed to its support. The firms are Avco Manufacturing Corp., Bell Aircraft Corp., Curtiss-Wright Corp., Fairchild Engine and Airplane Corp., Grumman Aircraft Engineering Corp., and Republic Aviation Corp. Another fellowship is offered in the name of the laboratory itself.

Three of the fellowships are sponsored for the first time this year. They are the Avco, Bell, and Cornell Laboratory grants.

First established in 1949, the fellowships are financed by the laboratory from fees earned on contract research. They provide $1200 a year plus tuition and fees, and are renewable. Fellows may use the aeronautical laboratory's research facilities and have opportunities for salaried work there during summers.

## Turk Engineers Visit

The first team of Turkish engineers and technicians to visit the United States under the E.C.A. program arrived at Cornell in June to begin a six months' study of American industrial methods.

The 14 men hold industrial management positions in Turkey in the textile, paper and pulp, steel, coke, and cement industries.

Their program is the first under the University's newly established Institute of International Industrial and Labor Relations. It will be conducted jointly in the New York State School of Industrial and Labor Relations at Cornell and the University's College of Engineering.

The team began with two months of classroom and laboratory work. Courses include management practice, labor-management relations, personnel administration, admini-

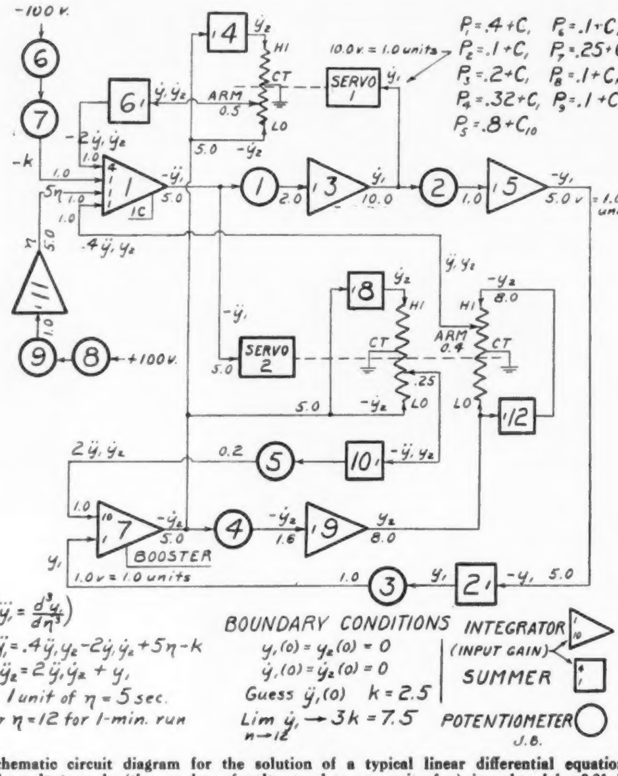
*(Continued on page 36)*

## Electronic Computers

*(Continued from page 17)*

sideration; if an integrator is operating over an interval of time only 1/60 as long as the physical time interval it represents, the voltage corresponding to the desired integral will be only 1/60 as large as it should be. (If a constant voltage of 2 volts is integrated over a period of two seconds instead of the 120 seconds this interval represents, the integral will equal 4 volts instead of the 240 volts which should be the result.) Therefore, in all integrating operations, the number of volts equal to one physical unit is reduced by a factor equal to the ratio of a physical time interval to the corresponding REAC time.

Loading of the potentiometers must be taken into consideration to avoid errors. Connection of the arm of a potentiometer to a resistor, unless it be of large value in comparison to potentiometer resistance, will cause an appreciable drop in voltage between the arm and ground since the resistor acts as a shunt. Potentiometer settings are corrected for loading with an input resistor of an amplifier and for loading of one potentiometer on another (necessary for values below 0.1, since the inaccuracy of potentiometers becomes significant for small settings). The one-gain input resistor of an amplifier is of high enough resistance to make the loading error insignificant in the connection of a summer or integrator to the arm of a servo potentiometer, but the four or ten-gain inputs should not be used with a servo; nor should a potentiometer be connected to a servo output. The REAC amplifiers have four or five output terminals (ordinary potentiometers and servo potentiometers naturally have only one), but if too heavily loaded (as with more than three potentiometers) they give inaccurate response and must be connected to one or two "boosters," electronic devices which compensate for loading distortion.




**Schematic circuit diagram for the solution of a typical linear differential equation. The voltage scale (the number of volts equal to one unit of n) is reduced by 0.01 in servo multiplication, and is increased by a factor of 5 in integration (because of time scale).**

This "closed-loop" type of circuit used to represent a differential equation will not start of its own accord. Initial conditions (values of variables and their derivatives when t=O) must be known, and unless there is some sort of forcing function (i. e., some constant or a function of the independent variable), at least one of the initial conditions must be different from zero. In other words, there must be some sort of exciting signal at the start of a run.

Boundary conditions are sometimes necessary to restrict the solution of an equation; e. g., a variable may be required to approach a certain value after a definite interval of time. Often initial conditions or parameters have to be guessed or adjusted till the right solution is found. With a linear equation it is possible to choose arbitrary parameters and, by a linear combination of various runs, to find the parameters which give a solution satisfying the given conditions. (With linear equations, multiplication of initial conditions by a constant causes the solution to be multiplied by the same constant, and addition of initial conditions gives a solution equal to the sum of the solutions of the equation for the original sets of initial conditions.)

#### Other Functions Represented

A function of any variable, not necessarily time, can be fed into a REAC circuit by means of a device known as an "input-output table." It consists of a drum, onto which a graph of the function is fastened, and a tracing arm, which slides back and forth along the length of the drum, moving a contact on a sort of potentiometer coil inside the instrument. The independent variable controls the angular displacement of the drum; i.e., the voltage representing the variable (usually a linear function of time obtained by the integration of a constant voltage, though not

*(Continued on page 30)*

## Electronic Computers

*(Continued from page 28)*

necessarily so) is applied to the appropriate input terminal so that the drum rotates at a speed determined by the time derivative of the variable. Voltages corresponding to the extreme values of the ordinate axis, which represents the dependent variable, are applied to the ends of the resistance coil, and the desired function is taken off the arm. This instrument may be used as an output table by having the position of the arm (provided with a pencil instead of a tracing head) controlled by a variable voltage obtained from some point in the REAC circuit.

Information as to the variation in size of functions produced in the circuit is obtained by connecting circuit amplifiers to a four-channel recorder. Graph paper moves through this recorder at a predetermined constant rate, while a pen in each of the four channels moves in accordance with the voltage signal input. The sensitivity of each channel is controlled by a dial on the front of the instrument. Knowing this and the voltage scale at the point in the circuit to which the recorder is attached, one can take readings for the value of a variable at any time during the run.

To return to the comparison of the electro-mechanical type computor, it is interesting to note that the Rockefeller Differential Analyzer makes use of an input table similar to the device used with the REAC. However, preparation of a problem is quite different. Three mechanisms read a tape input which gives instructions for connecting shafts of adders and integrators, fixing gear ratios, and setting counters for initial conditions. Several typewriters express the output of the Differential Analyzer in printed numbers; results may also be obtained in the form of a graph. As with the REAC, no equations involving two or more independent variables (partial differential equations) can be solved.

### Many Uses

Electronic analogue computers of various types find many applications. In pure research, instruments such as the REAC can solve linear and non-linear differential equations which would otherwise be difficult or impossible to solve; they can be used in a trial-and-error method of varying parameters to find an optimum physical system. They are valuable tools for the numerical solution of scientific and engineering problems and for industrial process control computations.

Single-purpose electronic computers are employed as integral parts of radar systems used for blind bombing, gunfire control, and navigation. Also, in application to a kind of problem not discussed in this article, the REAC and similar instructions can be used as "simulators" to simulate actual operating conditions of mechanical devices by satisfying certain equations and thereby make it possible to study the reaction of a mechanical system to various electronic control instruments. The versatility of these computers or simulators has been and will continue to be of great value in war and peace-time problems.

New portable radiotelephone, of less weight but longer range, designed and built by RCA engineers.

## Deane W. Malott

*(Continued from page 11)*

University finances. With a dwindling endowment and soaring maintenance costs the problem is accentuated by a proportional decrease of private grants, causing research, expansion, and salary increases to be curtailed. One possible solution would be the acceptance of corporate and governmental grants, but Mr. Malott has asserted that these would be acceptable only if there were no inhibiting strings attached.

Having faced similar problems at Kansas, President Malott is also cognizant of many pressing campus affairs, commenting, "I put at the top of the list of needs for Cornell housing facilities and a central library. We are losing able students today because they are not choosing to come to Cornell when universities all over the country are building dormitory quadrangles in anticipation of an era of education in which the university cares for its students 24 hours every day, seven days a week. . . If you go into the library on a winter day, you have the impression that you are in an ill-lit, ill-ventilated monkey-house."

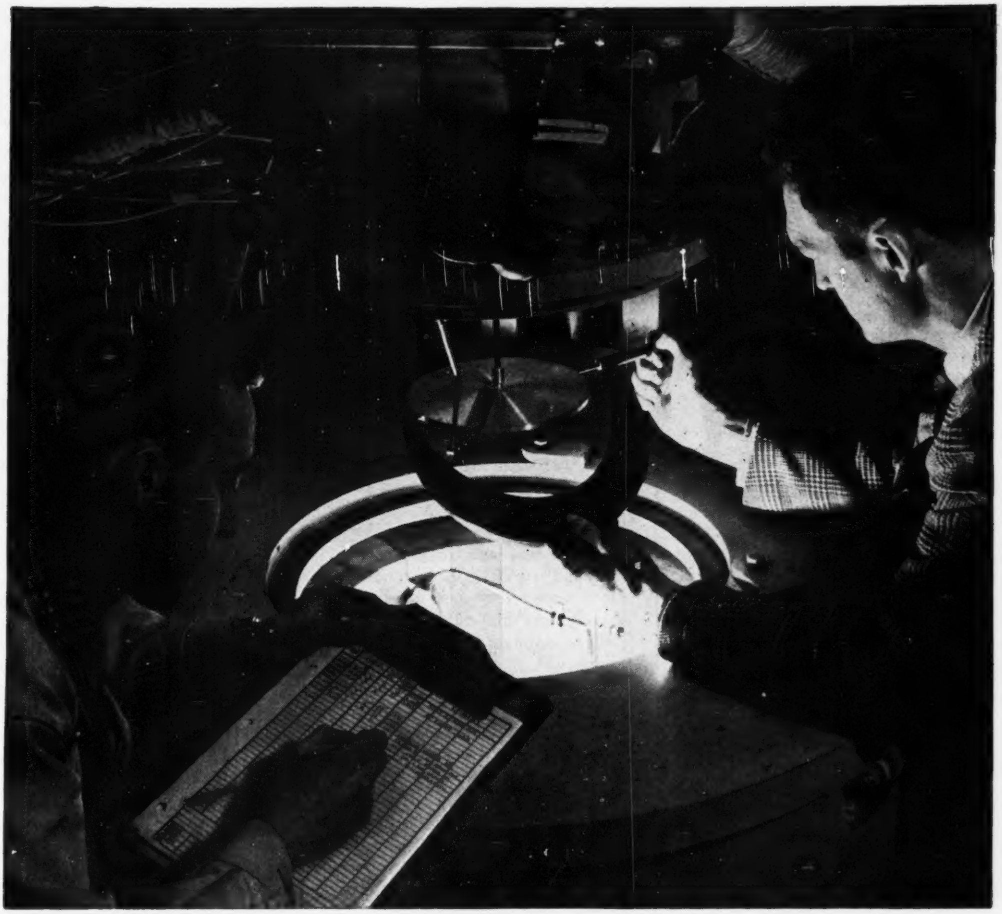
He is also disturbed by the nation-wide reports of an increasing tendency toward cheating, which he feels may be indicative of a post-war disintegration of morals, and by the fact that modern society is failing to imbue an ethical spirit within its younger members. Perhaps Deane Waldo Malott's philosophy can best be expressed by the words of his inaugural address:

"Old ideas of initiative and thrift and integrity are disappearing. Government, like a giant octopus, is wrapping itself around more and more phases of our lives. . . There must come a new thinking into America which insists that government be not an end in itself but a servant of free enterprise, an expediter of the energy and initiative of a free people. Otherwise, an unseen paralysis sweeps over the nation, and we sink slowly from the free republic to the welfare state, to the handout state, to the police state. . .

"But the outlook is far from dark as the academic year opens today. . . . The old fraidy-cats who hate and condemn the liberalism in our colleges never suggest additions to the store of human knowledge, but always subtractions. They want us to leave out all that is interesting and vital, the great current issues, the great controversies in the form of government, systems of finance, and policies of ethics on which they wish neither professors nor students to take sides. . .

"I am joined by the entire Cornell faculty, staff, and student body, that we together shall transmit. . . an even stronger University. . . through the great forces of liberal and professional education which fear neither truth nor heresy."

D. S.
G. W. S.



# EDITORIALS

Every board wants to do something new for its magazine, to add something or do things in a better way. This year is no exception. The Engineer will continue its efforts to improve itself, in content, presentation, and interest. But this year we have the extra incentive of a brand new cover.

Twelve years ago this fall marked the adoption of the familiar cover that has distinguished the Engineer since just before the war. We hope our new cover will not mark the beginning of new hostilities. On the contrary, it should be a symbol of continued improvement and innovation for the Engineer.

Many ideas and suggestions for the grand facelifting had been made, but it finally remained for a group of architects under Professor F. M. Wells to come up with just the right answer. At our request, Professor Wells presented the problem to a class in Senior Design 107 as a twelve hour esquisse. A day of concentrated labor resulted in over twenty-five different cover patterns.

After careful judgment by architecture critics and members of our board, on the basis of appearance, versatility, and practicability, the creation of John Insco Williams was selected. For his contribution to the Engineer, John received a twenty dollar prize and the privilege of starting a new generation in Engineer covers. We hope you like it as much as we do.

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"An impartial scientific survey by doctors proves . . ." This often-used sentence has just about become the forefront of the American advertising system. The ad men of this country have given up frightening people into purchasing their product; have forgotten the lines that guarantee beauty; and are now concentrating upon proving to the public that their product is either made more scientifically, can be used more scientifically, or its use will make its user more scientific.

This shift in advertising to the scientific approach, of course, has developed gradually from the yesteryear cries of the patent-medicine man, whose "scientific proof" consisted of a helper who, day after day in front of the prospective purchasers, sprung from his crutches claiming miraculous benefits from the particular snake oil on sale. As the gullibility of the population decreased, the proof needed increased, until the final positive proof, that which was used by Copernicus, Harvey, and Darwin, was hit upon by the advertising copy-writer—Science.

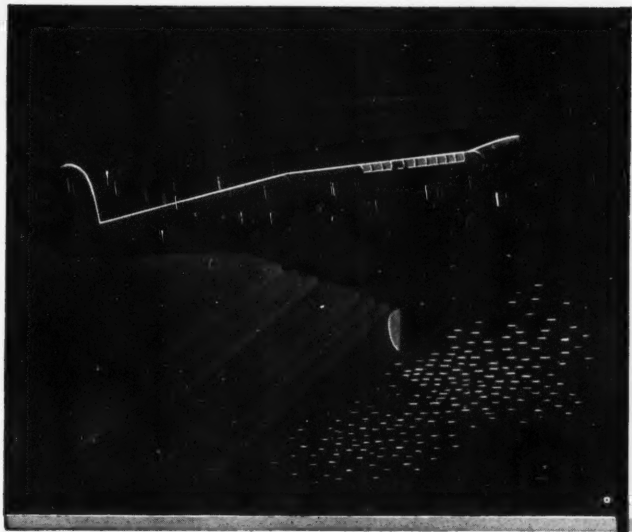
Science is an imposing word. It brings to the public the concept of years of painstaking analysis, careful sifting of data, complete impartiality, grouping the data, looking for a reason, and testing and retesting any conclusions. And this approach is usually made by men with years of higher learning. There is no wonder that the layman listens respectfully whenever the word Science is mentioned.

But the unfortunate situation is that some of these men of science just are not scientific! Given the same set of data, two different scientists often reach diametrically opposite conclusions. This is possible, because the two men can be in different fields of science; for example: an engineer and a psychologist. Or personal motivation can cause an erroneous or biased interpretation. It is this bias that hurts scientific development.

As an example of this, there is a book in circulation concerning an evaluation of time study, written by an engineeer. For some odd reason, his tables and graphs are unlabeled, and he slurs over the units of measure. By doing this, he is able to draw unwarranted conclusions. Again, later on in the book, he deliberately misapplies statistics.

This then, is the danger: the misuse of the scientific method by people who claim to be, and by all rights should be scientists, in order to prove a conclusion that had been made prior to the beginning of the study.

Let's not allow opinions to be cloaked in the word of science.



## News of the College

*(Continued from page 26)*

strative engineering, production layout, and cost analysis.

During September the group will visit industries throughout the country. In October and November each man will be placed in a plant for on-the-job observation and training in his special field.

Project manager is Prof. Rudolph Corvini of the School of Industrial and Labor Relations. Prof. Harry J. Loberg, director of the Sibley School of Mechanical Engineering at Cornell, is in charge of the group's engineering courses.

## Belcher Visits Iran

Prof. Donald J. Belcher, head of the Cornell Center for Integrated Aerial Photographic Studies, and two members of his staff visited Iran to help to develop ground water resources in the country's underdeveloped areas.

Invited by the Iranian government, they spent two and a half months in field study and photographic exploration for the project. An office in Teheran served as base for the work.

Members of the center staff who accompanied Professor Belcher were Mrs. Nancy Davies and Dr. Jamshid Amouzegar.

## Dr. Smith Returns

After an absence of a half year Dr. Lloyd P. Smith, director of the School of Engineering Physics has returned to Cornell. Dr. Smith was at Oak Ridge during this period, doing government research. In his absense Professor G. Grantham was acting chairman of the Department of Physics and Professor T. Cuykendall was acting Director of the Department of Engineering Physics. Within this period, also, Prof. Cuykendall was appointed Assistant Director of the School of Engineering Physics.

## A.S.M.E. Meets

The Cornell Student Branch of the A. S. M. E. held its first regularly scheduled meeting on Thursday evening, October 4. Following the introductory remarks made by Bob Siegfried, a film dealing with the fabrication of aluminum beer barrels was shown. Eager to examine the articles first-hand, forty-six thirsty engineers gathered around the topic of the film soon after in the Engineer's Lounge, and quickly consumed its contents—after having inspected it closely of course. So concluded a most succesful meeting.

Of noteworthy interest is the fact that this year's A. S. M. E. public speaking contest will be held in February. The group also plans several interesting programs for future meetings, having arranged for talks by representatives of major industrial concerns. The speakers will discuss topics of interest to all fields of engineering.

## Thorpe Appointed Professor

Appointment of Raymond G. Thorpe as Assistant Professor of Metallurgical Engineering has been announced recently.

Professor Thorpe, who originally comes from Herkimer, New York,

*(Continued on page 28)*

## News of the College

*(Continued from page 38)*

took his undergraduate training at R. P. I. in chemical engineering. Upon graduation in 1942 he became an ensign in the United States Navy and served for over four years as a deck officer of an aircraft carrier in the Pacific.

After discharge from the navy as a full lieutenant, he came to Cornell where he took his masters degree in physical chemistry. He then went to work for the Monsanto Chemical Company as a research and process development engineer. Under the sponsorship of the American Foundrymen's Society, he came back to Cornell in 1949 to do research work on the high temperature properties of steel casting sands. This summer he was made an Assistant Professor of Metallurgical Engineering.

## Englishmen Study Here

Under a Marshall Plan program of academic and in-plant training in engineering, Great Britain has sent two men here to study in Cornell's School of Electirical Engineering.

Graham Booker of Sale, Cheshire, England and John Hamilton of Nottingham, Kent, England will study under a program arranged by the Institute of International Education for the Economic Cooperation Administration.

The academic part of the training will be for one semester and the rest of the year will be spent in practical work at industrial plants or public works agencies.

## American Physical Society

Cornell University played host to the Fluid Dynamics Division of the American Physical Society for a meeting on the "Dynamics of High Temperature Gases" on September 11-12 in Olin Hall.

Forty scientists from universities and laboratories throughout the country presented papers on combustion and detonation, shock waves, general hydro-dynamics and related topics.

Director William R. Sears and Professor Arthur Kantrowitz, both of the Graduate School of Aeronautical Engineering, presided at two of the sessions.

## Pete Rose

*(Continued from page 21)*

and an All-American Honorable Mention. Pete also served on the Freshman Class Council later being elected to the Sophomore Class Council too.

The following year he received the Atmos Award for being the outstanding sophomore in his class. This was coupled with the receipt of a John McMullen Undergraduate Scholarship for the second time.

In view of the aforementioned facts it is hardly surprising to learn that Pete totes around an impressive list of honor societies and campus organizations. He is now president of Tau Beta Pi, vice-president of Atmos and claims membership in Pi Tau Sigma, Mu Sigma Tau, Red Key and Sphinx Head.

Of course a college education is not all work and no play. So it is with Pete. The center of his social life is his fraternity, Tau Delta Phi, where he holds down the position of treasurer. He enjoys swimming for recreation too and has put his aquatic abilities to good use by working past summers as a swimming instructor and waterfront director at a camp.

All during his four years here Pete's primary interest has been, quite naturally, aeronautics. In order to take courses pertaining to this field, he overloaded his program whenever possible, carrying as many as twenty-three and twenty-four hours a term. When he graduates he hopes to be halfway towards his masters degree in aero engineering.

He has gained quite a bit too from his experience as an industrial co-operative student with the General Electric Company. This summer he studied and worked with gas turbines and is at present conducting his senior research project along the same lines.

This year Pete has received an opportunity to put some of his technical training to good use. He is teaching a Hotel School course in refrigeration. It has nothing to do with aeronautics, but he's enjoying it just the same.

## Weldspan

*(Continued from page 9)*

sion joints as desired.

*Spacers* — Combining the functions of highway curbings, floor stiffeners and floorbeam spacers are assembled I-sections, rising 18 inches above floors and extending some 4½ feet below floor level. Expansion joints spaced as with floor expansion joints.

*Bracing* — The welded rod and tubular tower design affords enough welded joints to take care of wind and sway bracing. In addition, all the welded joints in the floor assembly make it rigid against side and vertical sway as well as against twisting stresses. And all in addition to portal and floor tower bracing. Likewise tower pier bracing.

*Expansion Joints*—In order to eliminate impact at expansion joints, interlocking teeth slide back and forth at floor level. One, two, or three such expansion joints surely would suffice.

All welded construction.

## Techni-Briefs

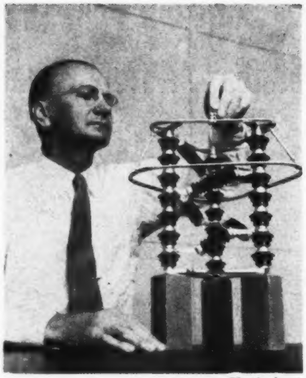
*(Continued from page 20)*

hands of motorist. However, even in a clean engine embedability is not dispensable, for grit, dust, and oil impurities, gathered in usage, may cause excessive wear.

Bearings must be designed with sufficient embedability to tolerate the largest particles they may encounter. The most effective means is a soft coating or facing on the bearing. This facing must be kept as thin as possible since fatigue results from a facing too heavy. Therefore, the thickness of this coating should be just sufficient to equal the diameter of the largest particle it may encounter minus the oil film thickness between bearing and journal.

## New Lightning Arrester

Westinghouse Electric Corporation has developed a new high-voltage lightning arrester which is only half as tall as former high-voltage arresters that require large structural steel supports. The new type SV station type arrester



*—Westinghouse*

**Model of New Lightning Arrester.**

features a zig-zag arrangement of the arrester units that eliminates the need for such supports. Lightning surges are carried groundward through a series of arrester units that spiral down between the three vertical columns. For use on 230-kv lines, the arrester stands 10 feet high, and is more efficient, less costly to install, and more easily maintained than previous designs.



## Switchgear

*(Continued from page 13)*

is to compare the current entering and leaving the windings of large generators or transformers, the lines connected to buses, or the terminals of transmission lines. The relay which compares these currents is called the "differential" relay and operates when a fault causes more current to enter the protected circuit than leaves it. For long transmission lines it would not be economical or physically practical to balance directly within one relay currents from both ends of the line. To accomplish this comparison, electronic means are used to transmit the information from one end of the line over carrier channels to the other end of the line where the comparisons necessary are made.

The distance a fault is from the substation may be detected by the use of a relay which compares the changed characteristics of a faulted line to the characteristics of the unfaulted line. This relay can then determine if the substation breaker should clear the fault or if a more distant breaker should be required to clear the fault.

Many other relays are available to act as guardians of power systems at the generating station, on the transmission lines, and throughout the distribution system.

## Protects Entire Plants

Switchgear are coordinated to protect and operate entire plants and systems. Protective relays and instruments, mounted on control panels and/or circuit breaker cubicles, together with control switches and other devices, provide the "brains" of the system. Circuit breakers to interrupt faults and disconnect these circuits in time to prevent further damage in the faulted circuit, provide the "brawn". Both of these tasks are done safely and expediently with modern switchgear when reliably designed, competently constructed, and correctly applied. In addition to these tasks, switchgear perform normal switching operations and, in some cases, automatically perform other operations such as motor starting, switching loads to emergency sources, and reclosing breakers after faults have been removed.


# "Put your *X there!*"

*"Ever have nightmares?*

"I don't, often. But I sure had one last night! Wasn't my usual one, being chased by a lion and falling off a cliff. In *this* dream it was Election Day. I was at the polls, kidding with some of the boys I knew . . . but they weren't kidding back. They looked sort of worried or scared or something.

"Anyway, I got my ballot, stepped into the voting booth and pulled the curtain. I wet the end of the pencil . . . to make my X's big and black. *Then the nightmare part began.*

"A tough-looking soldier stepped into the booth. He put his finger on the ballot and said, *'Put your X THERE! And THERE . . . and THERE . . .'* None of the names I'd picked, either. He had a big black gun pointing right at me.

"That was last night. Today, all day, I've been thinking about it. I'd known that was how some elections got settled in other places. But it never occurred to me before how lucky I was to be a citizen of *this* country. *Here* I vote according to my conscience, not a gun. And I do other things the way I please . . . like going to church, or picking out my own kind of job down at the Republic plant. Try that where there's no freedom!

"That's it . . . *Freedom!* We've got all the Freedom in the world. But, honestly now, do we *really* appreciate it? Do *you?* I admit I've done *my* share of griping . . . probably never will get over that habit.

"But, with Freedom-grabbers at work here as well as abroad, I want to be sure on Election Day that we're *all alone* in that voting booth. With nobody to tell us, *'Put your X THERE!'* No sir!"

# REPUBLIC STEEL

**Republic Building, Cleveland 1, Ohio**

***Republic BECAME strong in a strong and free America. Republic can REMAIN strong only in an America that remains strong and free*** . . . an America whose many thriving industries have brought the world's highest living standards to her people. *And in serving Industry, Republic also serves America.* Take, for example, the Food Processing Industry. Here untold millions of pounds of food are processed, refrigerated, packed, canned and frozen for the American table. And here Republic's gleaming Enduro Stainless Steel can be found on the job . . . in vats, cookers, sterilizers, mixers, coolers, to name but a very few . . . guarding faithfully the food your family eats.

* * *

*For a full color reprint of this advertisement, write Dept. H. Republic Steel, Cleveland 1, Ohio*

## Alumni News

*(Continued from page 19)*

**Walter C. Knox, C.E. '29,** is resident engineer on the $42,000,000 Jim Woodruff Project of the Mobile District, Corps of Engineers, Chattahoochee, Fla. The project includes a fixed crest spillway, powerhouse with three 10,000 KW generators, a switchboard, and earth dyke.

**J. Douglas Colman, M.E. '32,** executive director of Maryland Hospital Service and chairman of the National Blue Cross Commission, is vice-president for financial development of the Johns Hopkins University and the Johns Hopkins Hospital in Baltimore, Md. He had been a member of the Johns Hopkins Faculty.

**George L. Brainard, Jr., M.E. '38,** has received a Sloan Fellowship for a year of study at M.I.T., beginning June 9. The fellowships are given for training in executive development of industrial executives nominated by their employers. Brainard lives at 408 Crandall Avenue, Youngstown, Ohio.

**Kenneth A. Kesselring, B.E.E. '41,** assistant head of the engineering division of Knolls Atomic Power Laboratory, operated by the General Electric Company at Schenectady, has been selected as one of the nations outstanding young electrical engineers of 1950 by Eta Kappa Nu, national electrical engineering fraternity. Kesselring lives at 1916 Bentley Road, Schenectady.

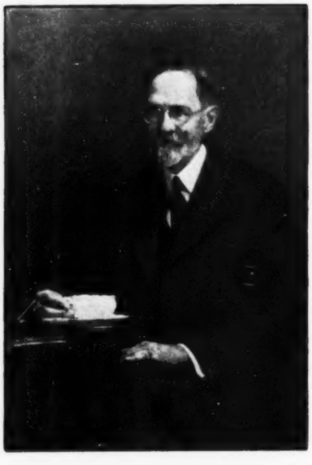
**Byron H. Leonard Jr., B.M.E. '45,** has returned to St. Louis, Mo. as chief engineer for Leonard Welding and Manufacturing Co. He lives at 56 Whitehall Court, Brentwood 17, Mo.

**Sanford W. Seidler, B.E.E. '46,** and Mrs. Seidler (Jean Gordon '49) now live at 134 Haven Ave., New York City 32. Seidler is chief of the microwave development section at Poland Electronics Corp., Brooklyn.

**Stanley F. Reiter, B.M.E. '46,** received the PhD in metallurgy at Yale in June and in July joined the research laboratory of the General Electric Co., The Knolls, Schenectady, N. Y.

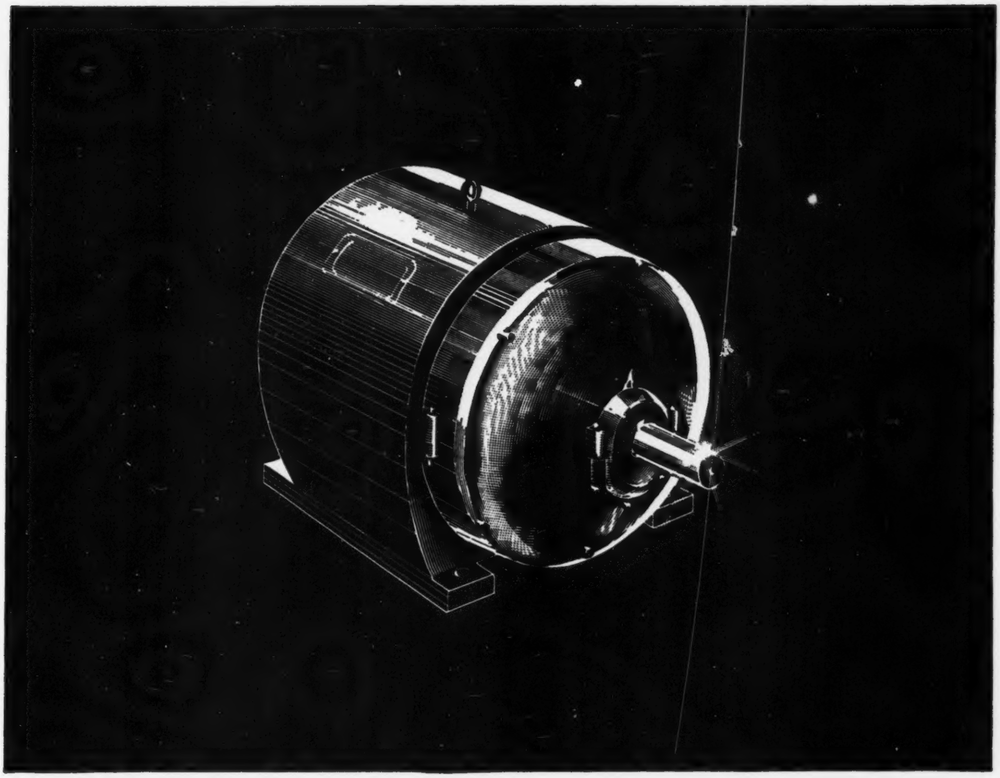
**Warren G. Herzog, B.E.E. '46,** has been in Spain for three years as an engineer with the Madrid branch of Standard Electric Co. In July, 1949, he married the daughter of a member of the staff of the American Embassy in Madrid. His address is Standard Electric SA, Madrid, Spain.

**Harold Glasser, B.E.E. '48,** returned to the United States in February, after spending fifteen months in Israel as local manager of customer engineering for International Business Machines Corp. He set up the first IBM engineering department in Israel and supervised Israeli engineers until they were able to run the department themselves. Glasser's address is 337 East Seventy-ninth Street, New York 21.



**Whose** picture is printed above, when was he last Seen on the Campus, and what is his Connection with the Cornell Engineer?

For the correctly documented Answer, the Engineer will award two Tickets to its Annual Banquet, and a Free Trip to Trumansburg.



**WORKHORSE OF INDUSTRY . . .**

Its granddaddy was a ponderous bi-polar Percheron that weighed hundreds of pounds . . . and cost hundreds of dollars more for the same horsepower. Yet this little miracle of efficiency runs for years without attention . . . has only one moving part. Today, motors are being built that operate safely in dusty, dirty, even explosive atmospheres.

Many nimble minds gave their ingenious best to make these improvements possible. Physicists, chemists, metallurgists, electrical and production engineers, designers, machinists . . . these and a thousand others contributed to the breeding of this alert little workhorse of industry.

**AMERICA WORKS LIKE THAT . . .**

Pulling together toward a worth-while goal is a work method uniquely American. Here, every art, every science, every human skill has the incentive and the opportunity to add its bit of invention or insight to the greater whole.

America can work like that because it has an all-seeing, all-hearing and reporting Inter-Communications System.

**THE AMERICAN INTER-COM SYSTEM . . .**

Complete communications is the function, is the unique contribution of the American business press . . . a great company of specially edited magazines devoted to the specialized work areas of men who want to manage better, design better, manufacture better, research better, sell better.

**WHY WE HAPPEN TO KNOW . . .**

The McGraw-Hill business publications are a part of this American Inter-Com System.

As publishers, we know the consuming insistence of editors on analyzing, interpreting, reporting . . . on making sure that every worth-while idea reaches interested people quickly and regularly.

As publishers, we know that people subscribe to business publications to keep abreast of what's new in ideas, methods and processes as reported by the editors and in products, materials and services provided by the advertisers.

**McGRAW-HILL PUBLISHING COMPANY, INC.**

330 WEST 42nd STREET, NEW YORK 18, N. Y.

HEADQUARTERS FOR BUSINESS INFORMATION

# STRESS *and* STRAIN...

**The Failure of the Engineer**

Now gather 'round students and you too can fret
O'er this incongruous problem, that I can't figure yet.
Its reason has plagued me, since I enrolled my first fall;
There's no logic behind it, no justice at all.
As a freshman they taught me slip-stick and trig,
No problems too complex, no angles to big.
I exempted by finals, not one disappoint.
Worked three thousand logs, never dropped a mantissa point.
As a soph I got better though the course got rough,
But as for my mind no problem too tough.
My credits were long as the Bronx directory
As I studied vectors, yes, even trajectory.
Work torque and power were most of my diction,
And my best pal remained the coefficient of friction.
I knew EE so well, I was consulted on hysteresis
By some guy named Einstein who was writing a thesis.
This vast store of knowledge is mine to command,
But it all seems to leave with this problem in hand.
I've used computations, tables, worked far into the night,
But this little arrangement just won't come out right.
After five years of college, tech electives galore,
Why do Arts students beat me on the dammed pinball score?

* * *

*Olaf Johnson went into a saloon and ordered a shot of squirrel whiskey.*

*"Sorry", said the barkeep, "but all we got is Old Crow."*

*"Yumpin' yiminy, Ay don't want to fly; Ay yust want to yump around a little."*

She doesn't drink.
She does't pet.
She doesn't go
To college yet.

* * *

An engineer's young son awakened from a peaceful slumber. Looking over his raiment, he yelled at his older brother:

"Did you pour water on me?"

"Naw."

"Must have been an inside job."

* * *

*Definition of bird that got caught in the lawnmower—Shredded tweet!*

* * *

Early to bed.
Early to rise.
And your girls
Go out with other guys.

* * *

Prof: "Wise men hesitate . . . only fools are certain."

Student: "Are you sure?"

Prof: "I'm certain."

* * *

*Old doll: "You know where little boys who smoke go, don't you?"*

*Little boy : "Yes'm, up the alley."*

* * *

Famous Last Words: "Oh hell, they won't bust a senior . . ."

* * *

As the eskimo said as he finished his story and got up off his cake of ice: "My tale is told!"

* * *

*He takes her to mystery plays because they love each shudder.*

One Arts student to another: "What's the matter, Bill, sick or something?"

Bill: "Yes, insomnia. I keep waking up in Psych and Biology lectures."

* * *

*"Did you hear about the poor girl engineer? She lost her slipstick."*

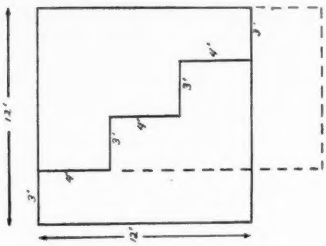
* * *

November Brain-teaser:

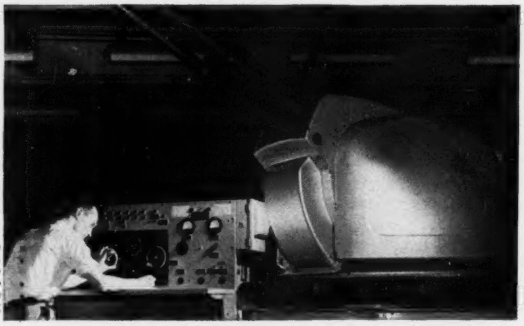
Now that you have solved last month's rug problem (see answer below), here's another rug problem, borrowed from the *Bent*: A man had a nine by twelve foot rug, in which he accidentally burned a hole in the center one foot by eight feet, parallel to the long edge of the rug. By cutting it into two and only two pieces, he succesfully joined it together again to form a rug ten foot square. The question: how did he do it?

Answers to October brain-teasers:

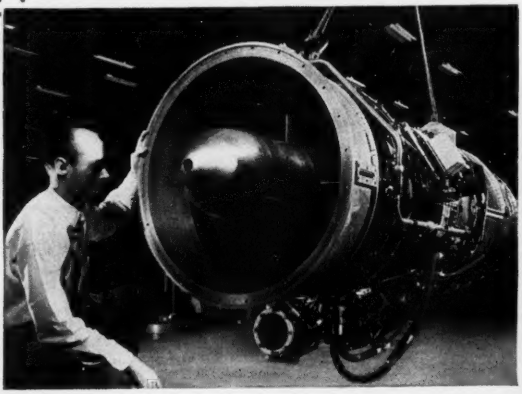
**Rug Problem:**




Dominoe problem: When arranged on the chess board, each dominoe must cover one black square and one red square. But the two diagonally opposite corner squares that are removed are the same color. Thus, no matter how the dominoes are then arranged, two squares of the other color will be left over, and since they are the same color they will not have a common side and thus cannot be covered by one more dominoe.



A gun turret for the B-36 bomber undergoes test as it comes off the assembly line at a General Electric plant.



An advanced model of General Electric's J-47 turbojet engine packs far more power within the same size.

G-E engineers developed this portable steering unit which enables Navy ships to be steered from any of several widely separated strategic positions.

# Ideas from college graduates at General Electric are helping U. S. mobilization

Add to the above the nuclear-powered aircraft engine that General Electric is developing for the Air Force . . . turbosuperchargers . . . guided missiles . . . radar . . . the plutonium-producing reactors which the Company operates at Hanford, Washington for the Atomic Energy Commission.

Into vital national projects like these are going the efforts of hundreds of scientists, engineers, chemists, physicists and other college graduates who are making their careers at General Electric.

There's a major reason why General Electric is asked to contribute to so many of these projects. The Company has prided itself on building an outstanding engineering, technical and business organization, one that can take the toughest problems and master them, one that can be a steady source of new ideas.

Young people from American colleges and universities, their skills and talents further developed through G-E training courses and rotational job programs, are forming the core of that organization and are the source of the ideas that are standing the nation in good stead.

*You can put your confidence in—*

**GENERAL ELECTRIC**